AGRICULTURAL ENGINEERING

JUNE · 1952

CENTENNIAL OF ENGINEERING 1852 1952

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Free . . . to

INSTRUCTORS

CLUB LEADERS

FARM ADVISORS

A PACKAGED PROGRAM ON SOIL AND WATER CONSERVATION

8 MOVIES

. . . 16 mm. in full color and sound. "Soil and Life" tells the whys and hows of conservation. "Strips and Curves"— erosion control on the Great Plains. Other titles: "Water Spreading," "Modern Farm Machines Bring Back the Range," "Broad Base Terracing," "Build Good Terraces," "Level Farming on Sloping Fields," "Building a Pond."

8 BOOKLETS

. . . written as companion pieces to the above films, clinch what the films teach. Your choice of materials for semi-humid and semi-arid conditions. Be sure to request enough booklets so that each member of your audience may take one home for further study and future reference. Booklets and films have identical or similar titles.

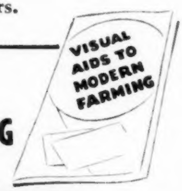
7 POSTERS

. . . 24 x 36 inches, are designed for impact at classroom distances and to supplement films and booklets. All material in this series is soundly practical, showing how to use ordinary farm tractors, plows, and scrapers. Here is information the farmer can take home and put to work saving soil and making dollars.

SLIDE FILM

. . . "More Benefits from Manure" and companion booklet show how to make best use of barnyard manure, one of America's most valuable farm crops. Most Case materials are purely educational; some include promotional matter. All films are loaned and printed matter is furnished without charge to instructors, club leaders, county agents, and other responsible persons, groups, and organizations.

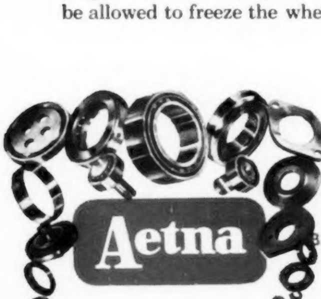
Here is flexible material for a fact-packed class hour or a full evening's club program, as you will. Read at right how to order.



60 TEACHING AIDS . . . NOW OFFERED

BE SURE YOU HAVE THE NEW VISUAL AIDS CATALOG

As its contribution to a prosperous, enduring agriculture, the Case Company has prepared some sixty educational items. The new Visual Aids catalog describes each and tells how to order. Get your copy, and schedule your choice of movies, etc. through your nearest Case dealer or Branch House. J. I. Case Co., Racine, Wis.



Aetna

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR JUNE, 1952

Vol. 33, No. 6

AGRICULTURAL ENGINEERING is regularly indexed by Engineering Index, and by Agricultural Index.

Volumes of AGRICULTURAL ENGINEERING, in microfilm form, are available (beginning with Vol. 32, 1951), and inquiries concerning purchase should be directed to University Microfilms, 313 N. First St., Ann Arbor, Mich.

INDEX TO ADVERTISERS

TO OUR READERS: Advertisers in this issue present their products and services for your scrutiny, with confidence in their engineering merit and capacity to meet the requirements for which intended, and with confidence in your appreciation of these contributions to engineering progress in agriculture.

AGRICULTURAL ENGINEERING is owned, edited, and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, Saint Joseph, Michigan.

SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $2.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

AGRICULTURAL ENGINEERING is a member of the Audit Bureau of Circulations.

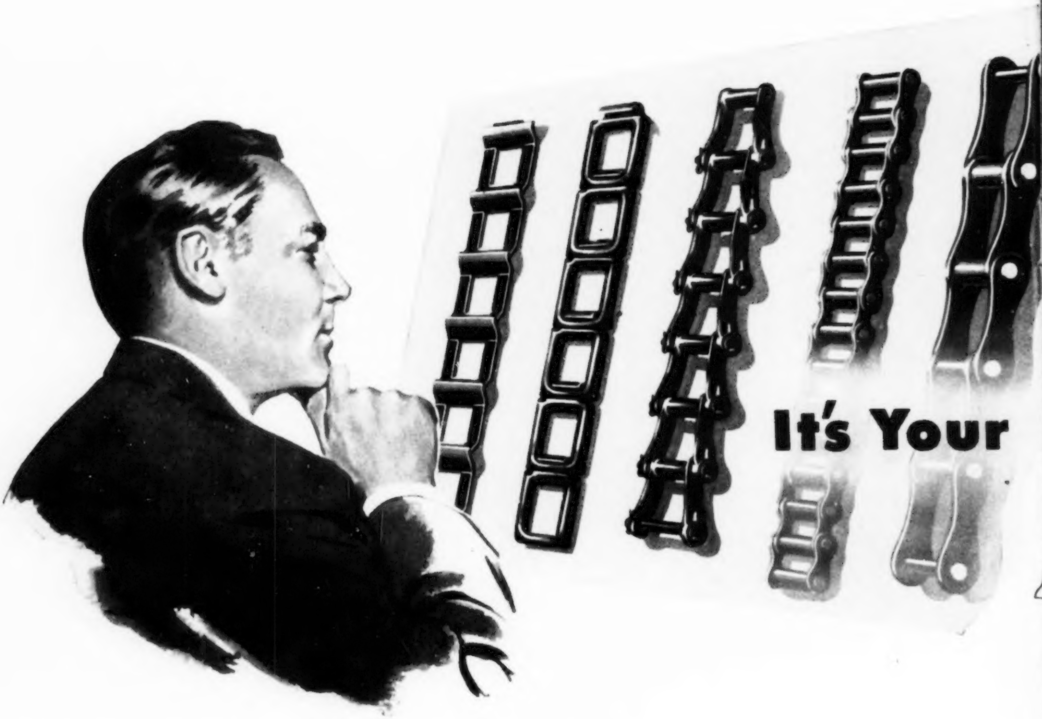
ADVERTISING REPRESENTATIVES

Chicago 2: DWIGHT H. EARLY
100 North LaSalle St.
Tel. CEntral 6-2184

New York 17: BILLINGSLEA & FICKE
420 Lexington Ave.
Tel. LExington 2-3667

RAYMOND OLNEY
Editor and Business Manager

505 Pleasant St., St. Joseph, Michigan
Telephone: 3-2700



When you make your chain selections from the complete Chain Belt line, your choice is virtually unlimited. Because the line is complete, there is sure to be the exact chain available that will most efficiently and economically perform the required function. Your job is to be certain you make the best possible choice. For example:

Perhaps you have been using a finished roller chain, yet speed and load conditions are such that a cast chain or an economical Baldwin-Rex® Double Pitch Roller Chain will do the job equally well at lower cost.

Then again, you may be using a cast detachable chain under conditions where a Rex® Steel Detachable Chain can perform the same function for less. It may be that you are having trouble with a timing application. Here, only finished steel roller chain will answer the need.

Your Rex Field Sales Engineer is specially trained to help you make the one best selection from our complete chain line. He is happy to consult with you concerning your application problems. He may be able to help you make substantial savings. Call or write your nearest Field Sales Office.

REX

BALDWIN-REX®

Chain

ATLANTA • BIRMINGHAM • BOSTON • BUFFALO
CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • EL PASO • HOUSTON
INDIANAPOLIS • JACKSONVILLE • KANSAS CITY
LOS ANGELES • LOUISVILLE

Choice ... Make The Most Of It!

FREE BOOKLETS AVAILABLE

A variety of useful literature is available to help you "make the most of it" in your chain selections. Some of the most popular items are listed here. Just check off those you want and mail the coupon. There's no obligation.

1. CARE AND MAINTENANCE OF CHAINS
Suggestions on how to get better service with less maintenance from your conveyor and drive chains.

2. BALDWIN-REX STOCK ROLLER CHAINS
Complete specifications, prices and descriptions of Baldwin-Rex Roller Chains, Couplings and Sprockets.

3. REX AND BALDWIN-REX CONVEYOR CHAINS AND ATTACHMENTS
Describes and illustrates various types of conveyors that can be constructed from our complete line of chains and attachments.

4. BALDWIN-REX CHAIN VISES
The story on the new Baldwin-Rex Chain Vise which makes cutting roller chain quick and easy.

5. REX STEEL DETACHABLE CHAINS
Story and specifications on this popular low-priced detachable chain as applied particularly to farm equipment.

6. UNUSUAL APPLICATION OF ROLLER CHAIN
28 pages of photos, blueprints and stories showing unusual, money-saving uses of roller chain.

7. REX Z-METAL CHAINS
A description of Rex Chain cast of Rex Z-Metal—approximately 25% stronger than the highest quality malleable iron.

8. BALDWIN-REX DOUBLE-PITCH ROLLER CHAINS
Facts on how you can cut costs and reduce weight by specifying Baldwin-Rex Double Pitch Roller Chain.

9. REX STOCK SPROCKETS
Rex Sprockets, carried in warehouse stock for over the-counter sale, cataloged by chain type and size.

Chain Belt Company 52-100
4680 W. Greenfield Ave.
Milwaukee 1, Wis.
Gentlemen:

1.☐ 2.☐ 3.☐ 4.☐ 5.☐ 6.☐ 7.☐ 8.☐ 9.☐
Please send me the items checked above.

Name..

Company.......................... *Dept*..............

Address..

City................................ *State*..............

Belt COMPANY
OF MILWAUKEE

MIDLAND, TEXAS • MILWAUKEE • MINNEAPOLIS
NEW YORK • PHILADELPHIA • PITTSBURGH
PORTLAND, OREGON • SPRINGFIELD, MASS.
ST. LOUIS • SALT LAKE CITY • SAN FRANCISCO
SEATTLE • TULSA • WORCESTER

HYDRAULICS FOR MOBILE EQUIPMENT

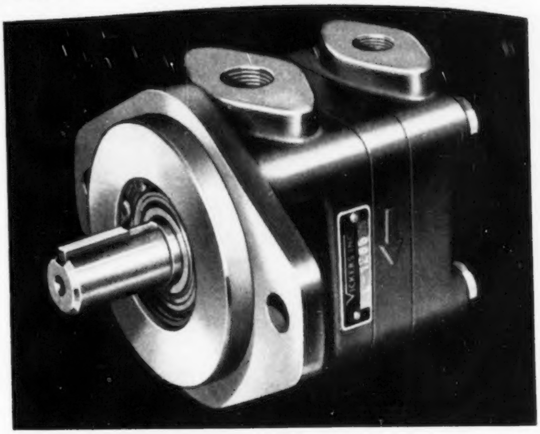
Mobile Equipment News

IMPROVES PERFORMANCE • CUTS COSTS

VOL. 1 — VICKERS INCORPORATED, DETROIT, MICHIGAN — NO. 1

NEW VICKERS SERIES V-100 PUMPS ADDED TO MOBILE EQUIPMENT LINE

Compact, efficient, rugged . . . this new and smaller addition rounds out the Vickers line of vane type pumps designed especially for mobile equipment. These pumps have established a reputation for doing a better job and lasting longer . . . at lower overall cost.



HYDRAULIC BALANCE MEANS LONGER PUMP LIFE

The two internal outlet ports are diametrically opposite each other. The same is true of the inlet ports. Thus equal and opposite thrust loads eliminate bearing loads due to pressure. Lighter bearing loads mean much longer bearing and pump life.

AUTOMATIC WEAR COMPENSATION MAINTAINS TOP PERFORMANCE THROUGHOUT PUMP LIFE

Radial compensation for wear is in the vanes. The vanes slide freely in the slots and are moved out into contact with the cam ring by centrifugal force . . . then held there by hydraulic pressure as it builds up. As normal wear occurs, the vanes just move further out in the slots to compensate. (Wear is minimized because all parts are lubricated by the oil under pressure.)

Axial compensation is by means of a pressure plate held to correct running clearance by pressure from the system. It automatically moves in to compensate as wear occurs.

Automatic compensation eliminates need for "run in" . . . efficiency is maximum the first time the pump is started. It also assures maximum delivery over a very long life, with none of the gradual falling off encountered where there is no wear compensation.

V-100 PUMPS AVAILABLE IN 3 CAPACITIES

The Series V-100 Pump is available in three capacities: 1.5, 2.5, and 4 gpm at 1200 RPM and 0 outlet pressure. This choice of three capacities with same exterior dimensions facilitates matching pump to the job.

Ask for Installation Drawing No. 152060.

GREATER MOUNTING ADAPTABILITY

Series V-100 Pumps are available in two mounting styles . . . flange (magneto type) and foot mounting. The pressure connection can be placed parallel, opposite to or at a right angle in either direction to the inlet by simply unbolting and rotating the pump head. Shaft drive is in either direction depending only on internal assembly.

NO-LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes expand and pumping begins.

OTHER VICKERS BALANCED VANE PUMPS FOR MOBILE EQUIPMENT

Series V-200 pump made in 4 delivery ratings—2 to 11 gpm.

Series V-300 pump made in 4 delivery ratings —12 to 24 gpm.

Series V-400 pump made in 2 delivery ratings— 28 and 36 gpm.

Series V-500 pump in 2 delivery ratings — 50 and 65 gpm.

4775

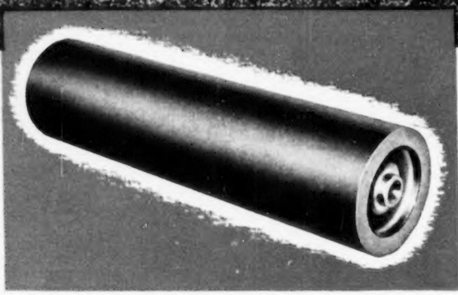
VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
1516 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) • NEW YORK (Metropolitan) • PHILADELPHIA (Metropolitan) • PITTSBURGH • ROCHESTER • ROCKFORD • ST. LOUIS SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

FOR DEPENDABILITY IN THE FIELD Engineer

Photo Courtesy International Harvester Co.

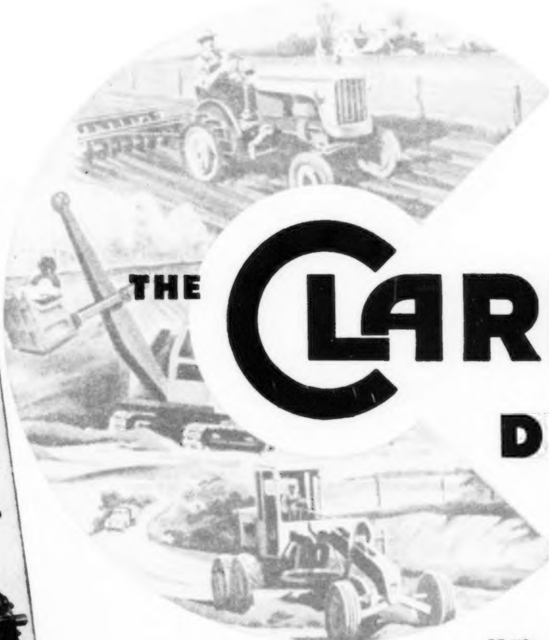


Rely on Dayton for rolls, too!

Need corn husking rolls . . . corn snapping rolls . . . flax rolls . . . draper rolls . . . rolls for *any* kind of farm equipment? You can depend on Dayton Rubber's technical leadership for rolls that will be a credit to your machinery, rolls that protect your equipment's reputation for dependability.

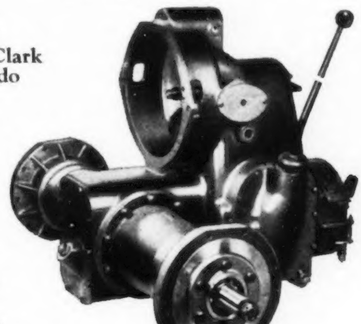
Dayton V-Belts ARE ORIGINAL EQUIPMENT ON THE NATION'S LEADING—

COMBINES • CORN PICKERS • FORAGE HARVESTERS
COTTON PICKERS • HAY BALERS • RAKES • MOWERS
WINDROWERS • CHOPPERS • SPREADERS
MILKERS • SPRAYERS, etc.



THE CLARK DRIVING UNIT

...an ingredient for dependable performance



It is a noteworthy habit of machines equipped with Clark transmission-axle units to do a good, efficient job—consistently, dependably.

That fact has led quite a number of leading manufacturers of heavy duty industrial equipment to call CLARK into consultation—to design a special driving unit for a new machine or for redesign of an old one.

There is this to be said for the results: the machines have been uniformly successful—so much so as to establish the Clark Drive Unit as an ingredient for dependable performance.

Working with CLARK may appeal to you, also—as strictly "good business."

This pocket size book briefly describes and illustrates Clark Products. You are invited to send for it.

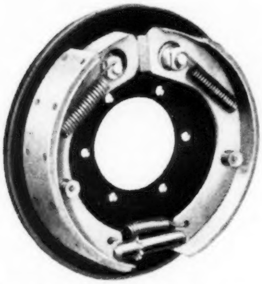
PRODUCTS OF CLARK — TRANSMISSIONS • AXLES • AXLE HOUSINGS • TRACTOR DRIVE UNITS • FORK TRUCKS AND TRACTORS • POWERED HAND TRUCKS • GEARS AND FORGINGS • ELECTRIC STEEL CASTINGS

CLARK EQUIPMENT COMPANY • BUCHANAN, MICHIGAN

Other Plants: **BATTLE CREEK** *and* **JACKSON, MICHIGAN**

Bendix Brakes

...designed and built specifically for **Farm Tractors**



The Bendix heavy-duty farm tractor brake has powerful and positive holding action in both forward and reverse. Rugged design assures uniform performance day after day, under the most severe field and road work.

Bendix brakes for farm tractors are specifically engineered for the hard going of field and road work. Tractor manufacturers—as well as automobile and truck manufacturers—look to Bendix as braking headquarters for their industry.

Backed by matchless research and manufacturing facilities, Bendix farm tractor brakes combine heavy-duty performance with extreme dependability—and at the lowest possible cost. Let Bendix farm tractor brake engineers help you solve your brake problems. Write for complete information.*

*REG. U.S. PAT. OFF.

BENDIX • PRODUCTS DIVISION • SOUTH BEND

BENDIX AVIATION CORPORATION

EXPORT SALES:
Bendix International Division, 72 Fifth Ave., New York 11, N. Y. • Canadian Sales: Bendix-Eclipse of Canada, Ltd., Windsor, Ontario, Canada

Eaton Free-Valves

can be applied to engines of all types and sizes

Eaton Free-Valves prevent the formation of stem deposits or uneven seat deposits; prevent local overheating, eliminating the principal causes of guttering; prevent valve stem sticking or scuffing. As a result, Eaton Free-Valves last many times longer. These benefits can usually be applied to an engine without costly design changes. Eaton Free-Valve Kits for motor cars and trucks are available from dealers.

You can utilize Eaton's long experience in this field by giving our engineers an opportunity to work with yours in the early stages of design.

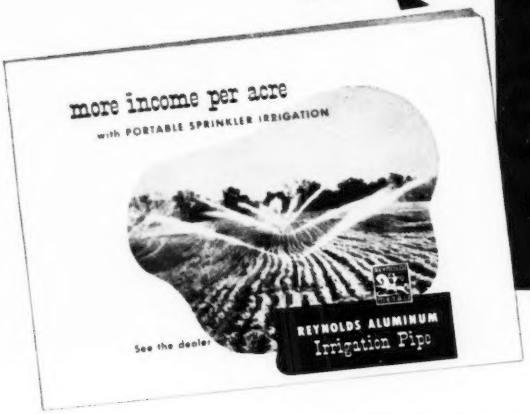
EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

VALVE DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

How to help farmers PLAN for PROFITS with PORTABLE SPRINKLER IRRIGATION



Send for this FREE Booklet

Portable sprinkler irrigation extends growing seasons and pasture feeding, improves crop quality, increases yields, assures drought protection and offers other important advantages, too. You'll find these points are covered in the aptly named booklet "More Income Per Acre" . . . and you'll also find informative data on planning for a portable irrigation system . . . and on the time and labor saving advantages of using lightweight aluminum pipe.

Use the handy coupon below to order your sample copy of this free, 12-page illustrated booklet. Additional copies for your group meetings are also available.

Remember – like you, the dealer in your area who sells Reynolds Aluminum Irrigation Pipe is familiar with local conditions. And like you, he wants to promote better farming methods. Consult him on specific irrigation requirements.

REYNOLDS METALS

REYNOLDS ALUMINUM

Member of A.S.I.E.M. Association of SPRINKLER IRRIGATION EQUIPMENT MANUFACTURERS

REYNOLDS ALUMINUM IRRIGATION PIPE FOR PROFITABLE IRRIGATION SYSTEMS

Reynolds Metals Company, 2588 S. Third St., Louisville 1, Ky.

Please send "More Income Per Acre," your new illustrated booklet on the application and advantages of portable sprinkler irrigation.

Name ____________________

R.F.D. or Street ____________________

Town ____________________ State ____________

New non-self-propelled combine utilizes seven Link-Belt chains: three sizes of Precision Steel Roller Chain, two sizes of Steel Link-Belt, and two sizes of Pintle Chain.

Get the right chain for your exact needs from the complete LINK-BELT line

WHEN you see a Link-Belt chain in operation, you can be sure it's built to a standard that assures longer chain life. Link-Belt makes a complete chain line; there's no need to use a so-called "general purpose" chain. Our engineers, working with your designers, can select the *one* specific chain that *best* meets a specialized need.

Call the Link-Belt office near you for detailed information.

LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa), Sydney (Australia). Offices, Factory Branch Stores and Distributors in Principal Cities. 12,790

Typical chains from the complete LINK-BELT line

Ewart Detachable Link-Belt, in malleable or Promal, for drives and power transmission.

Class 400 Pintle chain—cast links with closed pin joint, for light conveyor, elevator or drive duty.

Steel Link-Belt for moderate-strength power transmission and conveying.

Link-Belt Precision Steel Roller Chain, standard pitch, for high-speed drives.

EDITORIAL

Production Teamwork

WE ARE indebted to Howard A. Jongedyk (Associate Member ASAE) for calling to our attention a statement by Blake R. Van Leer, president of Georgia Institute of Technology, which merits consideration by agricultural engineers, among others:

"No one will deny that American production, science and technology are our ace in the hole in defending ourselves and the free world against the numerically superior forces that threaten us. The advance of both science and technology depends almost exclusively upon the supply of technically trained manpower, and the scarcity of such men is rapidly becoming the outstanding bottleneck to production also. In production we cannot ignore either the contributions of labor or of capital, for both are undeniably indispensable. To reward one unduly, at the expense of the other, is obviously unfair, since labor provides the operators and capital supplies the funds for the machines which make possible our tremendous production. Yet we have ignored a third, relatively small group which is fully as important to abundant production and which is morally as fully, or more fully, entitled to a fair share of the profits therefrom. I mean the engineers who conceive, design and build the complex machines of modern industry. Too often their salaries are less than the wages of the welders and bricklayers who give their creations physical form or of the men who turn the controls on the finished machines.

"If we are to improve the desperate technical manpower situation, we must make science and technology financially rewarding as well as intellectually stimulating. Capable, ambitious young men must come to view engineering and the sciences as a profitable career rather than a noble sacrifice. Then, and only then, may we expect a greater influx of top-quality youth into training for the professions which hold most promise of keeping America free and prosperous."

What is the most important position on the production team? Can either capital, labor, management or science be left out without seriously reducing production? Some progress in evaluating their respective contributions to production and their fair returns may result from the attention being given to this matter in recent years. It will have most significance if it is related to increased understanding of the teamwork by which all may share more generously in a larger production. Fighting for the lion's share of little is the primitive animal instinct. Individual initiative and enterprise developing and practicing the teamwork which is effective in producing more is relatively advanced civilization and a means of maintaining civilization. It is something which engineers can appreciate and help others to understand.

Fuel for Farming

JUST in case some otherwise well-informed people in high places may think that in an emergency, agriculture in the United States could reconvert to animal power, the practical impossibility of any such step backward has been clearly pointed out by R. M. Sharp in an article, entitled "Fuels for Defense Production in Agriculture," published elsewhere in this issue. Agricultural engineers may have occasion to bring the figures to further public attention.

Another indication of the extent to which the United States is committed to a petroleum-fuel basis of agricultural production is the fact that our agriculture is using about 50 gallons of petroleum motor fuel per year per individual in this country.

Undoubtedly there are opportunities to improve efficiency in converting fuel to power in farm engines, and in using that power for farm production. Any progress in this direction, however, is apt to be gradual rather than a sudden revolution greatly reducing our agricultural fuel requirement.

Should the supply of petroleum motor fuels available to farmers be drastically reduced, due to a defense emergency or for any other cause, every 50-gallon reduction would mean a reduction of one in the number of people this country can support at their present level of material wellbeing. Fuel for farming is important to the consumer interest in agricultural commodities and national defense, as well as to the producer interest. The United States is not only millions of tractors, but also millions of people, beyond any possibility of reconverting to animal power without bringing on a major human catastrophe.

The Airplane in Agriculture

ILLUSTRATIONS of the agricultural engineering considerations which may enter into any distinctively new approach to agricultural progress are found in the paper by Fred E. Wieck (published elsewhere in this issue), entitled "Development of an Agricultural Airplane."

The extent to which farmers have taken to the air is well known. Their experience has shown that something more than improvising by individual farm users and farm work contractors will be necessary to make the most of planes as farm equipment.

Pioneering farm plane research and experimental development in Texas rightly recognizes the job as one for teamwork between specialists.

In the spraying and dusting phase currently reported, the experience of flying farmers and contract flyers has been recorded and evaluated. Aeronautical engineers have developed an air frame embodying an effective compromise of the power, lift, take-off speed, operating speed, stalling speed, landing speed, maneuverability, dependability, ease of maintenance, and other characteristics desired. For research purposes they have provided maximum flexibility in material and equipment carrying capacity.

Chemical coverage required to achieve the desired biological results has been defined by appropriate agricultural scientists.

Physical means of satisfying the biological requirement on a practical operating basis, considering the flight characteristics of the plane, has been recognized as an agricultural engineering problem.

Distribution of materials from planes has involved a new range of ground speeds, release elevations, and width of distribution desired for economy. It has created a new engineering problem in uniform lateral distribution. Technical evaluation of these factors and means of dealing with them by modifications and recombinations of existing equipment, and probably by the development of some new equipment, is a sound approach toward increasing the usefulness of airplanes as farm equipment. The agricultural engineers who are working on it are extending the boundaries of their profession.

Hunger

IN ONE recently published book* the author advances the interesting proposition that hunger is the cause rather than the result of high population densities in many parts of the world. He cites considerable evidence in support of this viewpoint.

If there is substantial truth behind this proposition, it suggests the following implications for agricultural engineers:

1 Centers of high agricultural productivity per man-hour may spread by design, by emulation, by technical aid.

2 The means and desire for higher standards of living, with less perpetual hunger, may outrun population growth in more places than anticipated.

3 A sound technical aid program may prove more widely effective than has generally been anticipated.

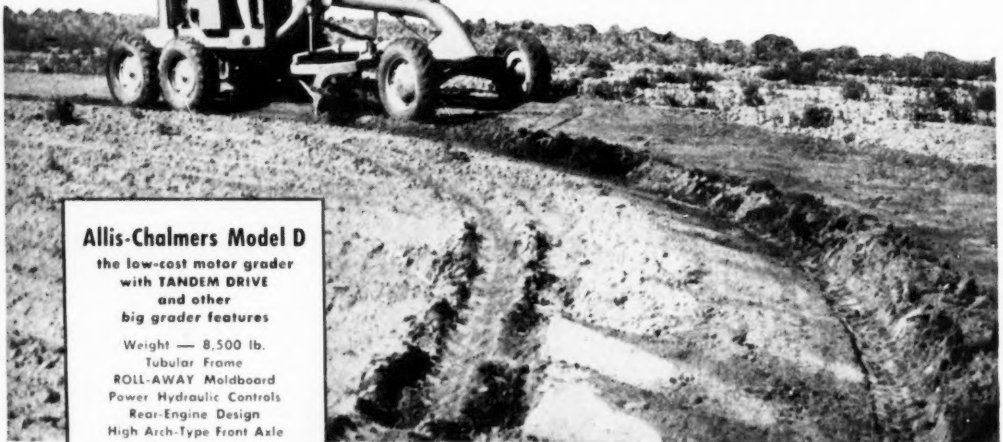
4 Cultures developing in productivity and free enterprise might cease to be political and social problem populations to neighboring countries.

It is not yet clear to us that people can be prevented from creating problem populations in areas and cultures not conducive to high productivity per person. The problem seems somewhat less overwhelming, however, in those areas where the food supply as currently developed is so limited that it supports comparatively small rather than large numbers of hungry people.

*The Geography of Hunger, by Josue de Castro. Little, Brown and Co. (Boston, Mass.)

LOW-COST # Earth-Moving Specialist

Handles Unlimited Jobs on Limited Budgets



Allis-Chalmers Model D

the low-cost motor grader with TANDEM DRIVE and other *big grader features*

Weight — 8,500 lb.
Tubular Frame
ROLL-AWAY Moldboard
Power Hydraulic Controls
Rear-Engine Design
High Arch-Type Front Axle
Drop-Down Transmission
Full Visibility

THE new Allis-Chalmers Model D Motor Grader gives the kind of earth-moving advantages that only a full-fledged, tandem drive motor grader can give — and brings this performance within easy reach of limited budgets. Rolls big loads fast, makes smooth water channels and terrace ridges, maneuvers easily, travels quickly from one job to another, yet it costs only 1/3 as much as large motor graders!

This grader also builds and maintains farm roads, handles ditching and sloping . . . with bucket attachment, loads material. And it's economical to maintain as well as to own. Any mechanic can service the 34.7 hp. gasoline engine. Parts are carried by all A-C tractor dealers.

Write for free catalogs or ask your Allis-Chalmers industrial tractor dealer to show you how the Model D can stretch conservation and road maintenance dollars.

•

Level it, slope it, ditch it, pile it — *or load it.* When it comes to moving dirt at low cost, the Model D is your machine. Rear-mounted hydraulic shovel with ⅝ cu. yd. bucket adds still further to its usefulness. Saves time, men and equipment on loading and stockpiling jobs . . . ideal for filling small gullies and ditches on terracing work.

Roll-Away is an Allis-Chalmers trademark.

ALLIS-CHALMERS
TRACTOR DIVISION — MILWAUKEE 1, U. S. A.

AGRICULTURAL ENGINEERING

VOL. 33 JUNE, 1952 NO. 6

The Kinematics of Tractor Hitches

By D. C. Heitshu

MEMBER ASAE

IN SPITE of having hitched plows and other tillage implements to power units, either animal or mechanical, for many years, there remains considerable mystery about what happens when implements and tractors are connected with one form of hitch or another.

The fact that a line of draft, or the soil reaction of a ground-engaging element cannot be seen may explain why hitches baffle many mechanically minded people. The need for a better understanding of a currently popular engineering problem is the reason for this paper.

The popularity of tractor-mounted implements never has been greater. The farmer likes the idea of a simple, easily controlled, integral unit made up of his tractor and the particular implement he wishes to use at the moment. However, to meet these wishes, on the part of the farmer, the agricultural engineer is confronted with an assortment of problems. This paper will not solve any of them, but perhaps it will help in evaluating the proposed mounting, and in designing the proper structure for the mounting, by attempting to explain the forces and kinematics involved. Knowledge of this kind should help in securing a mounting or hitch that will give satisfactory performance, because it is based upon sound engineering analyses.

To reach this objective the various mountings in use on current tractors will be reviewed. The kinematics of the hitch will be outlined, and using common simulated conditions one method of analyzing the forces acting on the tractor will be presented. Because procedure and principles, rather than results, are the objective of this treatise the various examples contain assumptions that are adjusted to simplify the examples. When the problem is understood the answer is obtained easily.

The tractor used is assumed to weigh 3200 lb and to have a wheelbase of 82 in. The center of gravity is 32 in ahead of the center line of the rear axle. The static weight distribution is approximately 61 per cent on the rear wheels and 39 per cent on the front wheels, or 1951 lb and 1249 lb respectively. The loaded radius of the rear tires is 24 in. The drawbar is 15 in above the ground, and the drawbar pin hole is 26 in to the rear of the rear axle center line. Although the tractor changes in detail from hitch to hitch, it is assumed that the foregoing data will remain constant.

The implements used in this study are a two-bottom lister, a disk harrow, and a subsoiler or chisel. The lister is assumed to have a horizontal draft component D of 1200 lb, and a vertical component V of 200 lb until coulters are used. With coulters the vertical component is reduced to 100 lb. The total draft H is the resultant of D and V: $H=\sqrt{D^2+V^2}$. H is active along the "line of draft" forming an angle β with the horizontal: $\tan\beta=V/D$. Hence the line of draft of the lister has an angle of 9 deg 28 min without coulters, and 4 deg 46 min with coulters. To simplify this analysis, it is assumed that the draft of the implement and its angle of action does not change for the lister, even though its construction is varied for the different hitches.

For the disk harrow, $D=1200$ lb, and $V=0$. Therefore, $H=1200$ lb, and $\beta=0$ deg. For the chisel, $D=1200$ lb, $V=693$ lb, $H=1385$ lb, and $\beta=30$ deg.

In analyzing the forces involved, and their effect upon the tractor, some of the lesser forces have been omitted. These include acceleration, wind resistance, gyroscopic action, etc. These are of importance under extreme conditions only. These forces can be applied in individual cases when desired. In this paper interest is centered upon securing traction, maintaining good steering, keeping the tractor-implement combination safe, and observing the kinematics of the particular hitch being analyzed.

The tractive reaction is taken at a point C which is the locus of the soil reactions against the drivewheel. Point C results from R_1 the supporting soil reaction, R_3 the tractive reaction, the plastic flow of the soil, rolling resistance, and tire tread lug action. Rubber tires are assumed, and although point C (Fig. 2) does not move any great distance from the vertical center line for most soil conditions when rubber tires are used, in these analyses C is taken as 2 in forward of the rear axle center line. The tractive coefficient is assumed to be 0.5, and the tractor is level in all cases. The effect of slopes fore and aft, or crosswise, may be added readily when desired. Fig. 2 illustrates the relative position of point C.

DRAWN IMPLEMENT AND CONVENTIONAL DRAWBAR

Many tractors and implements work together using a simple pin and clevis coupling. If the hitch is properly made, this arrangement provides a reasonably efficient arrangement that is simple, durable, and with the larger implements rela-

A paper presented at a meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers at East Moline, Ill., April, 1952.

The author: D. C. HEITSHU, chief engineer, John Deere Harvester Works, East Moline, Ill.

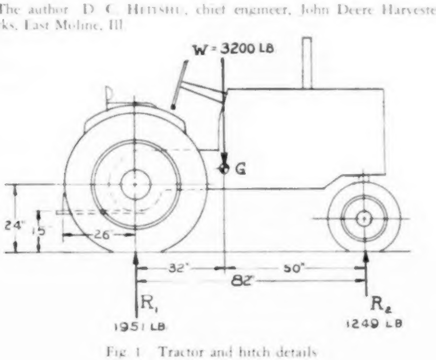


Fig. 1 Tractor and hitch details

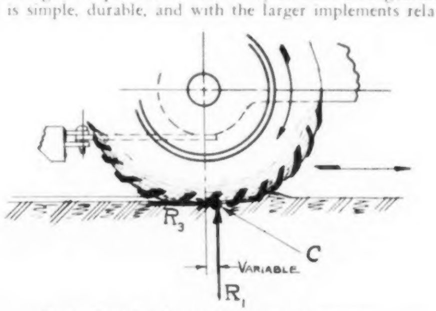


Fig. 2 Point C indicates the locus of soil reactions

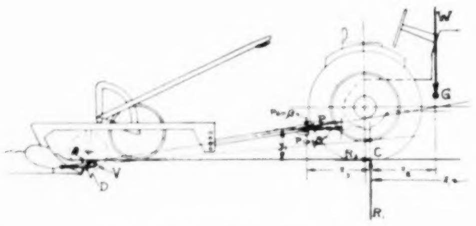


Fig. 3 Hitch for tractor and drawn lister

tively easy to connect. Remote control hydraulic cylinders, safety hitches, rubber tires, and other recent innovations help this simple hitch to maintain its popularity in spite of the newer tractor mounted hitches.

In this analysis it is assumed that the hitch is correct, i.e., the extended line of draft passes through the lister hitch to the tractor drawbar pin hole. This is illustrated in Fig. 3. Hitched in this manner the implement gage wheels carry the minimum load and therefore do not add to the draft of the implement. However, it is not always possible to hitch correctly. The lister, for example, cannot be properly hitched when the coulters are used, unless the hitch plates are lowered, and the implement hitched farther from the tractor, or the tractor drawbar lowered. A more practical and very common solution is to weight the implement so that the line of draft raises sufficiently to enable a satisfactory hitch to be made.

Farmer practice appears to favor having the normal line of draft above the drawbar pin hole, and making the line of draft coincide with the drawbar by adding the necessary downward loading to the implement gage wheels.

Returning to the correctly hitched lister and taking moments to determine the soil reactions, we have the following:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 + x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 50}{80} + \frac{200 \times 108}{80} + \frac{1200 \times 15}{80}$$

$$= 2495 \text{ lb}$$

$$R_3 = 0.5\,R_1$$

$$= 1247 \text{ lb}$$

$$R_2 = \frac{W x_2}{x_1} - \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} - \frac{200 \times 28}{80} - \frac{1200 \times 15}{80}$$

$$= 905 \text{ lb}$$

The analysis indicates favorable operating conditions, except for R_3. The tractor could stand some weighting to reduce operating slip of the driving tires, as the cushion between required pull and calculated pull is only 17 lb. Checking against static conditions shows an addition of 544 lb to the rear wheels of the tractor, while the front wheel weight has been reduced 344 lb. This weight shift may be increased and a satisfactory R_3 obtained by lengthening the drawbar, or increasing the slope of the line of draft by adding weight to the implement. Care must be exercised in changing the drawbar to be certain that the front wheel weight is not reduced to the point that the tractor is no longer safe. It is for this reason that rear wheel weights, either liquid or cast iron, are preferable to a longer or higher drawbar.

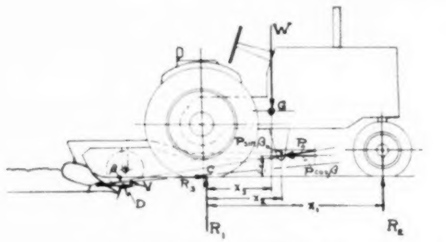


Fig. 4 Tractor hitch with mounted lister

MOUNTED IMPLEMENT WITH REAL HITCH POINT

The high-clearance, all-purpose tractor brought into prominence the mounted implement which provides the farmer with a more maneuverable unit, and at the same time reduces headland width. Many forms of mounted implements have been and are being used. Some are semi-mounted, while others are fully mounted and controlled from the tractor.

These mounted implements have one common feature — they all have a real hitch point. Usually this hitch point is located somewhere under the belly of the tractor with the draft member of the implement attaching directly to the hitch point. Such an arrangement is shown in Fig. 4.

Mounted implements in this group may be gaged for working depth by means of gage wheels, suspension from the tractor, or an adjustable hitch point. Frequently a combination of the foregoing is used to take care of the rather large variations in soil conditions, work to be done, etc., etc. The raising and lowering of the implement may be accomplished manually, or by mechanical power through a variety of mediums.

The details of the hitch depth control and lift may vary to a large degree, but the reaction upon the tractor is the same in principle. Exploring the conditions presented in Fig. 4, and resolving the moments, the following equations result:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 - x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 50}{80} + \frac{200 \times 46}{80} + \frac{1200 \times 9}{80}$$

$$= 2250 \text{ lb}$$

$$R_3 = 0.5\,R_1$$

$$= 1125 \text{ lb}$$

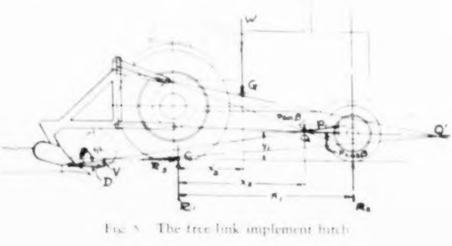


Fig. 5 The free-link implement hitch

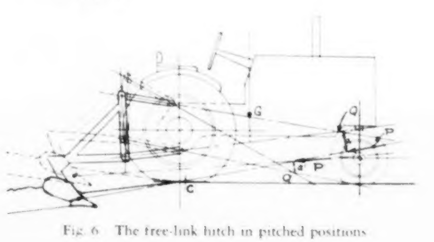


Fig. 6 The free-link hitch in pitched positions

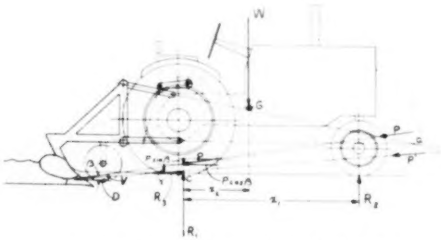


Fig. 7 The infinitely variable fixed-link hitch

$$R_2 = \frac{Wx_2}{x_1} + \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} + \frac{200 \times 34}{80} - \frac{1200 \times 9}{80}$$

$$= 1150 \text{ lb}$$

The tractor is heavy in front and must have weight added to the rear wheels for the tractor to pull the designated lister. The rear axle loading may be helped by moving the implement rearwardly so that the draft line will fall at a greater distance above point *C*. This change may be undesirable because of its effect upon tractor balance with the implement in transport position, and must be checked carefully. The mounted implement does not load the tractor rear wheels as heavily as the drawn implement. The weight increase being 299 lb with the mounted implement, as compared with 544 lb for the drawn implement.

MOUNTED IMPLEMENT WITH VIRTUAL HITCH POINT

In recent years the three-link hitch has become popular. This hitch lends suitable stability to the mounted implement, provides a hitch point at the desired position without interference with tractor parts, and intrigues both the farmer and the implement and tractor engineers. Fig. 5 illustrates one of these devices.

The first three-link hitch to be examined is the type having free links and a virtual hitch point. In this hitch the implement operates in a condition of equilibrium with the line of draft passing through the intersection of the link center lines extended. Gaging is secured by adjusting the balance of the implement, and/or the linkage system so that the line of draft passes through the virtual hitch point in the desired position. Fig. 5 indicates an adjustment of the top link to compensate for the addition of coulters to the lister, assuming that the working depth is to remain the same as without coulters. Without coulters the virtual hitch point is at *Q*, while with coulters the hitch point must be located at *Q'*.

Again resolving the moments, the soil reactions to the tractor wheels are:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 - x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

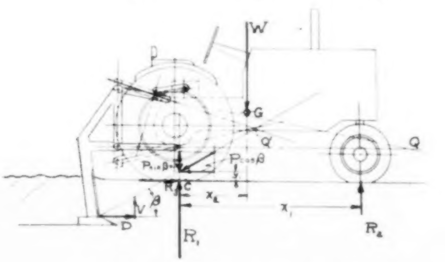


Fig. 9 Subsoiler with fixed-link and free-link hitches

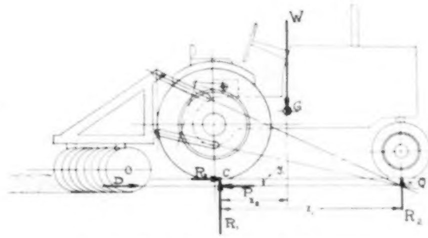


Fig. 8 The fixed-link hitch with disk harrow

$$= \frac{3200 \times 50}{80} + \frac{200 \times 22}{80} + \frac{1200 \times 13}{80}$$

$$= 2250 \text{ lb}$$

$$R_3 = 0.5\, R_1$$

$$= 1125 \text{ lb}$$

$$R_2 = \frac{Wx_2}{x_1} + \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} + \frac{200 \times 58}{80} - \frac{1200 \times 13}{80}$$

$$= 1150 \text{ lb}$$

The results are identical with those secured with the mounted implement having a real hitch point. This is true because the implement is in the same relative position to the tractor in both cases. Again the rear wheels must be weighted with cast iron, or liquid ballast. To obtain further rear-wheel loading from the implement reaction, it is necessary to move the lister rearwardly or increase the angle β by making the implement heavier.

Tractors and implements do not operate on level ground but a small portion of the time. For this reason the three link hitch should be explored under rough ground conditions. The conventional three-link hitch has merit in the fact that it permits the implement and tractor to pitch (vertical longitudinal movement) and to yaw (horizontal longitudinal movement) in respect to each other. However, in the third plane it has been found desirable to resist roll (rotation about the longitudinal axis) as many implements are not stable in the lateral plane.

Fig. 6 illustrates what happens when the implement drops or raises from the normal level land position with a virtual hitch-point linkage. Shown in solid lines is the lister with the lower link hitch 4 in below the position shown in Fig. 5. In this position the virtual center of the hitch links is at *Q* and the instantaneous out-of-balance is equal to *Pa*. This out-of-balance moment will cause the implement to raise bringing the line of draft closer to *Q*. As the lister raises, *Q* will approach *P* causing *a* to diminish rapidly. In addition, it is to be noted that the lister is tilted nose down to some degree in respect to the ground line between the rear wheel and the lister base, which should increase the slope of the line of draft and further reduce *a*, so that the virtual hitch point *Q* will be reestablished at a point slightly below the one shown.

With the implement up 4 in, indicated by the broken lines, the instantaneous center *Q'* is below the line of draft the distance *a'*, thus making the lister tend to run deeper. However, the implement is tilted nose up in relation to the immediate ground surface which should reduce the slope of the line of draft. This, plus a small lowering of the hitch, will quickly restore balance at the virtual hitch point.

MOUNTED IMPLEMENT WITH INFINITELY VARIABLE FIXED-LINK HITCH

This hitch, which is used on several of the large volume tractors on the market, is the three-link hitch just described with a draft-reaction controlled lift unit added to gage the

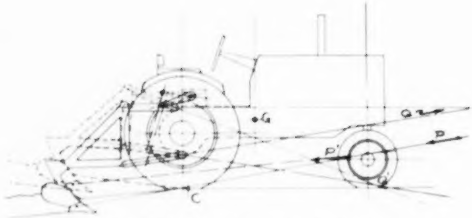


Fig. 10 The fixed-link hitch in pitched positions

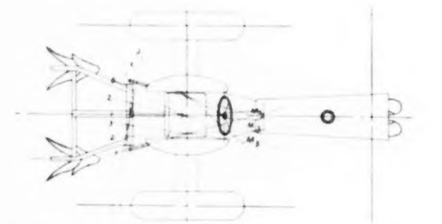


Fig. 11 This drawing illustrates the instantaneous swing point of the three-link tractor hitch

implement working depth in response to draft. The controlled lift unit in effect makes the hitch a fixed hitch that is infinitely variable in response to draft changes. However, when the line of draft (Fig. 7), along with force P acts, falls below Q, the instantaneous pivot of the hitch, the hitch ceases to be a fixed hitch and becomes a free-link hitch having a virtual hitch point. This change results from the lift being single action, i.e., the hitch lowers by gravity alone, but is raised by positive hydraulic force.

Fitting the lister with coulters lowers the line of draft. P' is below Q; hence with coulters the tractor and implement will function in the same manner as the free-link hitch, and reach a state of equilibrium with P' passing through a relocated Q. This is the maximum working depth of the combination. At any lower draft setting of the control lever than that required to pull the lister at its maximum depth, the draft reaction controlled lift will function, and the hitch becomes an infinitely variable fixed hitch. The maximum depth may be increased by adding ballast to the implement, to change the value of β, or by relocating the hitch links to lower the instantaneous pivot point Q.

To determine the weight transfer as a result of this hitch, moments are taken as follows:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 - x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 50}{80} + \frac{200 \times 80}{80} + \frac{1200 \times 3.33}{80}$$

$$= 2250 \text{ lb}$$

$$R_3 = 0.5\, R_1$$

$$= 1125 \text{ lb}$$

$$R_2 = \frac{W x_2}{x_1} + \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} + \frac{200 \times 0}{80} - \frac{1200 \times 3.33}{80}$$

$$= 1150 \text{ lb}$$

The results again point out the fact that the relative position of the implement and tractor determine the weight transfer, and not the hitch that may join the two. In the examples set up the conventional drawn implement has shown the larger weight transfer, 544 lb added to the rear wheels, as compared with 299 lb for the mounted implements. However, it must be remembered that a number of design factors enter into the over-all performance of an implement-tractor combination. Moreover, these factors can be arranged to give the optimum performance. Implement weight, implement position, length of upper and lower links, positioning of links, angle of links, etc., are but some of the items to be decided upon before selecting the most desirable tractor-implement hitch arrangement.

In Fig. 8 a disk is shown working at maximum depth with infinitely variable fixed-link hitch. Gaging by draft reaction, control is possible under the conditions indicated at any depth down to the one shown. The weight transfer is interesting in this case, as noted in the following calculations:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 - x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 50}{80} + O + \frac{1200(-3)}{80}$$

$$= 1955 \text{ lb}$$

$$R_3 = 0.5\, R_1$$

$$= 977 \text{ lb}$$

$$R_2 = \frac{W x_2}{x_1} + \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} + O - \frac{1200(-3)}{80}$$

$$= 1245 \text{ lb}$$

Implement penetration is secured by subtracting from the traction-producing weight of the tractor. It is obvious that weight must be added to the tractor rear wheels to obtain traction, or to the disk to secure penetration and thereby raise the line of draft above the horizontal. In practice it may be desirable to weight both the tractor and the disk. Transport balance and safety are the determining factors.

A chisel, or subsoiler, is shown attached to the tractor in Fig. 9. Both a draft-reaction-controlled, fixed-link hitch and a free-link hitch are indicated. The infinitely variable fixed-link hitch has its instantaneous pivot point at Q, while the free-link hitch has its virtual hitch point at Q'. The weight transfer is identical, and resolving moments, the soil reactions are:

$$R_1 = \frac{W(x_1 - x_2)}{x_1} + \frac{P\sin\beta(x_1 - x_3)}{x_1} + \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 50}{80} + \frac{693 \times 80}{80} + \frac{1200 \times 4}{80}$$

$$= 2753 \text{ lb}$$

$$R_3 = 0.5\, R_1$$

$$= 1376 \text{ lb}$$

$$R_2 = \frac{W x_2}{x_1} + \frac{P\sin\beta x_3}{x_1} - \frac{P\cos\beta y_1}{x_1}$$

$$= \frac{3200 \times 30}{80} + O - \frac{1200 \times 4}{80}$$

$$= 1140 \text{ lb}$$

These results point out the reason for the excellent performance of small tractors pulling mounted subsoilers, and the relatively poor job done by these (Continued on page 356)

Application of Electrostatic Charging to the Deposition of Insecticides and Fungicides on Plant Surfaces

By Henry D. Bowen, Peter Hebblethwaite, and Walter M. Carleton
ASSOCIATE MEMBERS ASAE MEMBER ASAE

THE dusting of agricultural crops has been a standard practice for controlling plant pests and diseases for many years. However, no one has ever denied the extreme inefficiency of the method as conventionally practiced.

In recent field tests dust recovery has been approximately 10 per cent with conventional field dusting, where dust recovery refers to the percentage of dust discharged by the duster that actually deposits on the plant. From this it is believed by the authors that under normal farm work the dust recovery seldom exceeds 15 to 20 per cent even on dense foliage. In an effort to increase the recovery of dust and to make that recovery more effective by means of better distribution, controlled electric charging has been added to the conventional dust-application process.

In the past, some considerable work has been done in the laboratory and field in an attempt to utilize the electrostatic forces that are present when dust particles possessing an electric charge are blown into the immediate vicinity of growing plants. In the main, field results did not live up to laboratory promises for the early workers and, because of the extreme undependability of the charging process used, many dropped the work with the feeling that the electric field was greatly overrated in its ability to cause particles to deposit on plant surfaces.

In electrostatic dusting the electric charge and the resulting forces are not substitutes for the dynamical forces active in conventional dusting, but rather are additional forces that are combined with the dynamical forces. The combining of the electrostatic and dynamical forces results in a considerable increase in dust recovery and usually in an improved distribution. With electrostatic dusting the forces active are exactly the same as for the conventional dusting, with the exception that the electrostatic forces are always present and active in aiding deposition. This causes dust to deposit on surfaces where it is impossible to produce dynamical forces of sufficient magnitude to cause deposition.

The major forces active in conventional dusting are dynamical forces, electrostatic forces, the resistance of the air to dust movement relative to it, leaf surface repulsion, and gravity. The dynamical forces are usually of most importance in causing deposition with conventional dusting and are due to the tendency of the moving particles to continue in a straight line due to their momentum when the air that has been carrying the particles is deflected by the plant surfaces. The electrostatic forces (due to friction) may or may not be of consequence, depending upon the relative quantities of the two signs of electricity present and the distribution of the electricity within the cloud. The resistance of the air to dust movement through it allows the particles to be carried to the various surfaces of the plant by means of a stream of air. This same air resistance is largely responsible for the low dynamical catch (1)* and also limits the amount of electrostatic catch that may be expected. The only important way in which the factor of air resistance may be changed is by varying the particle size. The smaller the particles, the more important becomes the air resistance in preventing deposition. The surface repulsion forces are not fully understood, but it has been observed (3) that on bright sunny days liquid droplets of less than twenty microns in diameter will seldom settle upon a leaf surface under the force of gravity alone. This is probably due to "thermal repulsion" (4), a phenomenon by which small particles are acted upon by a force when in a thermal gradient. Gravity is a very small force compared with the other forces involved, except in the case of very large particles. From the standpoint of material efficiency it is generally considered that it is desirable to use as small a particle size as can be effectively placed upon the plant surfaces. Present practice is tending toward the use of a material which has been screened through a 325-mesh sieve. This will yield particles from less than a micron to particles having 44 μ (microns) as their smaller dimension. Particles less than ten microns in diameter are very difficult to precipitate with dynamical forces alone, but electrostatic forces will precipitate them.

GENERAL THEORY OF ATTRACTION

The following is a simplified theory of the attraction of charged dust to a growing plant. Needless to say, this explanation though correct in the general sense is not adequate to calculate the forces. However, this explanation in terms of elementary physics will serve to show the relationship present.

There are two basic laws in electrostatics: No. 1, opposite electrical charges attract and like charges repel; and No. 2, a charged body or cloud will induce an equal and opposite electrical charge on any conducting body placed near it. If the conducting body is insulated from the earth, the charges will be separated upon it as in Fig. 1(a). If the conducting surface is earthed, the separating line between the plus and minus charges appears at the earth's surface and the body then contains a charge of one sign, and this sign will be opposite to the sign of the charge on the inducing rod as in Fig. 1(b).

In Fig. 2, which further represents the situation of Fig. 1(b), there is shown upon the plant a plus charge induced by the cloud of minus particles according to the second basic law. The curved lines shown running between the plus charges

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Power and Machinery Division.

The authors: HENRY D. BOWEN and PETER HEBBLETHWAITE, graduate students in agricultural engineering and WALTER M. CARLETON, associate professor of agricultural engineering, Michigan State College, East Lansing.

*Numbers in parentheses refer to the appended references.

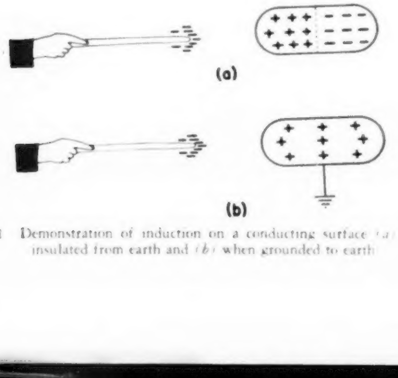


Fig. 1 Demonstration of induction on a conducting surface (a) when insulated from earth and (b) when grounded to earth

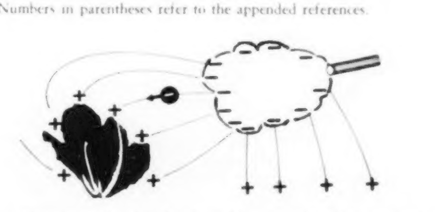


Fig. 2 This shows the plus charge on the plant induced by the cloud of minus particles and attraction of minus charged particles to plus charged plant

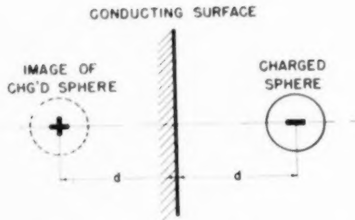


Fig. 3 This sketch illustrates a charged sphere approaching a conducting surface

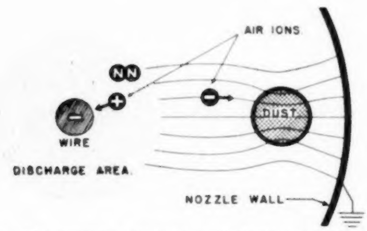


Fig. 4 This shows how the build-up of the air ions on the dust particles takes place in practice

on the plant and the minus charges on the cloud are called lines of electric flux which are analogous to the lines of magnetic flux near the poles of a magnet. The lines of electric flux are curved in exactly the same manner as are magnetic lines of flux between the poles of a magnet.

If a dust particle from the cloud is placed in the space between the cloud and the plant, it will tend to follow a line of flux from the cloud to the plant by virtue of the first law. Since the particle is negative, it will be repelled by the cloud and attracted by the plant. Because of the curved nature of the lines of flux, it is possible to coat all sides of a body by dusting from one side only.

The force of attraction of a charged particle to a plant surface is composed of two parts. The first is due to the action of the charged particle's own electric field as a conducting surface is approached; and the second part is the action of external electric fields upon the electric field of the particle. If the external fields are directed toward the plant, then the particle will be driven toward the plant surfaces.

A single charged particle of either sign will be attracted to any conducting surface which it approaches in accord with the principle known as the "image force of attraction".

Consider a charged sphere approaching a conducting surface (Fig. 3). The force of attraction of the sphere for the surface is given by Coulomb's law for point charges of unlike sign. The second charge necessary for Coulomb's law is the image of the real charge located behind the conducting surface and carrying a sign opposite that of the real charge. This law gives the true force of attraction only when the size of the particle and the distance d are of such proportions that the particle may be considered a point charge. This law then gives the force $F = Q^2/4kd^2$ dynes. Where the charge Q is in electrostatic units (*esu*), k is the dielectric constant of the medium ($\simeq 1$ for air), and d is the distance of the real charged particle from the surface in centimeters. Calculations show that the image force is of importance from the surface up to approximately 0.1 mm distance. At a distance of 0.1 mm for a 10-micron-diameter particle carrying a high charge, the image force will be of the order of magnitude of the force of gravity. At 0.03 mm distance, the force of attraction will be greater than ten times the force of gravity.

The second part of the force of attraction, called the "field force" is due to the fact that in some manner a charge opposite to the charge on the particle has been induced on the plant surface creating the situation of law No. 1. The field force is given by the equation $F = EQ$ dynes where the field intensity E and the charge Q are given in *esu*. Fortunately the field force is significant at distances from the surface up to several centimeters from the surface. However, the combinations of forces and velocities may be such as to prevent deposition of those particles at a distance approaching one centimeter or greater from the surface.

For optimum results the particles must be individually charged to a high value and all of the particles in the cloud to the same electrical sign. Otherwise the field intensity due to the cloud will be less than the maximum and many of the particles, when both kinds of charges are present, will combine and thus neutralize each other before they can be deposited on the plant.

The method of charging used by the early workers, with the exception of Hampe (2), has been that of friction charging. Friction charging occurs in conventional dusting and accounts in part for the variability of results of conventional dusting. Friction charging yields charges of both signs in the same cloud when different materials are mixed; it cannot be depended upon to occur at all at high relative humidities, and is so variable throughout an average day that it is not considered suitable as a method of charging except for special cases.

The method of charging used by the authors and Hampe (2) is called the ionized electric field method of charging. This method was first developed for use in industrial smoke cleaning. In this method the particles of dust after being mixed with the air are passed through a charging nozzle, which contains air ions of one electrical sign only. These air ions are driven across the charging nozzle at right angles to the path of the air-dust mixture and are moving very rapidly under the influence of a strong electric field. The air ions encounter the dust particles as they cross the path of the air-dust stream and are attached to the dust particles. It is the build-up of the air ions on the dust particles that gives the charge. Fig. 4 shows how this strong electric field and the air ions are formed in practice.

Fig. 4 shows the end view of a metal cylinder. The cylinder is connected to the ground side of the power supply. The wire shown in the sketch is coaxially positioned with respect to the

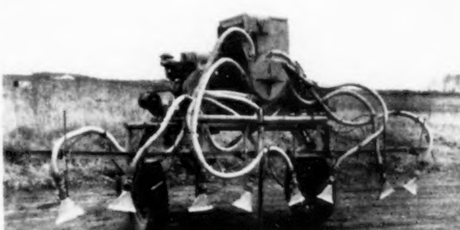


Fig. 5 (*Top*) For the field tests an 8-outlet duster of conventional design was adapted for use with the electrostatic unit • Fig. 6 (*Bottom*) Power for charging the dust on the field duster came from a 6-v automobile storage battery carried on the machine

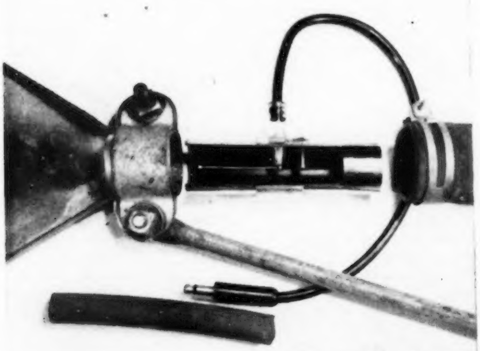


Fig. 7 A cutaway view of the charging nozzle of the electrostatic duster

cylinder, carries a 12,000-v d-c potential, and is insulated from the cylinder. By the second law of electrostatics there are plus charges induced on the inside of the cylinder wall. In the dotted area surrounding the negative wire is a very intense electric field which is accompanied by a violet glow known as a corona glow or discharge. Within this corona glow neutral air molecules are converted by electron collision into plus and minus air ions. A plus air ion is an air molecule with an electron missing. A minus air ion is an air molecule with an extra electron.

Consider a dust particle passing through the cylinder from the reader into the page. The lines of electric flux pass from the wire, through the dust particle as shown and to the inside of the cylinder wall. From law No. 1 the plus air ions formed in the corona-glow area will move to the negative wire and become neutralized. By the same law the negative air ions will be driven along the lines of flux and many of them will become attached to the dust particle where they will remain. There are tremendously large numbers of these negative air ions flowing and thus a large charge can be quickly put on the particle. The maximum charge that can be put on the particle depends on the strength of the field and the size of the particle. When the maximum charge is reached the force of the field trying to drive negative ions onto the dust just equals the force of repulsion between the negative air ions and the now negative dust particle. If the dust particle is very small and is left in the cylinder for a few hundredths of a second, it will be driven to the cylinder wall by the force of the field, which principle is used for smoke cleaning purposes. For dusting purposes the particle must be in the charging nozzle long enough to pick up a useful charge but must be discharged from the nozzle before it is driven to the wall.

DUSTING TESTS

We thus have the necessary theory to explain how the charging of fine particles can be achieved, and, with a simple laboratory model of the charging equipment, it was possible to demonstrate definite improvements in the recovery of dust on metal plates and on test plants. Generally these demonstrations showed very definitely in favor of charged dust, but there were variations from time to time, from really spectacular results, in some instances, right down to the inconclusive in others. In view of this uncertainty, and with the ultimate aim of evolving a practical method of electrostatic dusting, two groups of tests have been carried out. The first group, the laboratory tests, have been done under controlled conditions to answer such questions as: "Will the machine work under humid conditions?" "For how long does the dust retain its charge?" The other group of tests, the field tests, aimed at determining the practicability of the method in use, and at estimating the method's worth from a biological point of view (the control of insects and diseases and its effect upon the plants themselves).

Fig. 8 Histograms showing results, in percentages, of actual measurements of the amount of lead in dust recovered on bean leaves

Laboratory Tests. Whenever electrostatics are involved, the question of atmospheric moisture must be raised. Friction charging, for example, the crackle which can be heard on combing the hair with a plastic comb, is very susceptible to humidity. Under conditions of high relative humidity, a comb will rarely exhibit any electrostatic charge, and it was with this in mind that the following tests were made.

The tests were carried out in a small room where as far as possible the temperature was held constant, and the humidity varied from 40 to 100 per cent. Small metal plates were dusted with a laboratory model duster, half of the number with charged dust, half in the normal way with uncharged dust. These test runs were made at a number of different humidities in the range previously mentioned.

The results showed quite conclusively that dusting with charged dust could be carried out satisfactorily at 100 per cent humidity, and that even at this humidity the charged dust showed a significant improvement over the uncharged. At the high humidities, however, the improvement gained by charged over uncharged dust, was considerably reduced; specifically, in one instance the improvement was halved, but even at this level the balance in favor of charging was considered to be worth while.

Subsequently, dusting was satisfactorily carried out in the field at 100 per cent relative humidity without any difficulty with the equipment.

The influence of temperature upon dust deposit using charged dust has also been briefly investigated. From this test it was concluded that the effect of temperature (humidity remaining constant) was only slight, and was not sufficient to present any difficulty in the field.

Tests on the retention of the charge by dust particles were also carried out in the laboratory. In these it was shown that a charge was still present on the dust when it had travelled 33 ft from the duster nozzle (or a time lapse of 20 sec), and that this charge was still sufficient to give a significantly better deposit on test surfaces than did uncharged dust which had travelled the same distance.

In the use of the charging nozzles in the field it was necessary to choose a working voltage and amperage (the amperage depends upon the applied voltage in somewhat the same way as it would depend upon the voltage applied to an ordinary resistance wire), and in view of the existence of several unknown factors, this choice was somewhat arbitrary. There are, however, certain broad limits which can be set for the voltage. The lower limit is the minimum voltage required to produce a corona discharge on the needle (5000 to 6000 v in this case) and the upper limit, that voltage which will cause arcing between the needle and the nozzle wall when dust is flowing (somewhat in excess of 14,000 v).

In an attempt to determine how critical the current input is in relation to dust deposit, a number of tests were made to compare the current used in charging with the amount of dust deposited. A range of 0—500 μa (microamperes) was used in a test with a single nozzle. (This nozzle was identical with those used on the field duster.)

This series of tests demonstrated that there is a definite relationship between the current used and the amount of dust collected, and furthermore that there is an optimum level for

the current. If this optimum current was either not attained or was exceeded, less advantage was gained from charging the dust. The results also indicated that this optimum current varies from dust to dust and to some extent with atmospheric conditions. In view of this, further and more extensive tests are envisaged to enable recommendations on optimum current to be made in more definite terms. From the tests which have been carried out it appears that the field model was operated with rather too high a current to obtain optimum results. Although the current was not at the optimum, there was, however, a definite advantage from charging the dust.

Field Tests. Summing up the laboratory tests, it is evident that here is a method which promises to improve the recovery of dust and to give better distribution between all plant surfaces. It is also apparent that electrostatic dusting will be quite a flexible method as evidenced by the tests at varying temperatures, humidities, etc., but before any step can be made in the direction of practical use, the method must be field tested.

For the laboratory tests, only small single-outlet machines were used, but for the field tests an eight-outlet duster of conventional design (Fig. 5) was adapted for use with the electrostatic unit. Subsequently, two other commercial dusters were fitted to take the test equipment and further trials made with these.

Power for charging the dust on the field model came from a 6-v automobile battery carried on the machine (Fig. 6). Once charged, one battery will operate the machine for a considerable number of hours, or, alternatively, the tractor electrical system can be drawn upon. The charging nozzles on the field dusters were operated at 12,000 v. This high potential was derived from the 6-v supply by two steps. First, the 6-v supply was used to drive a dynamotor which in turn supplied an electronic unit, the "high-voltage supply" with a 300-v direct current. The high-voltage supply generated the required 100 μa at 12,000 v for each outlet. Details of the charging nozzles used are shown in Fig. 7.

COST OF CONVERSION OF FIELD DUSTER

The cost of adapting a duster in this way is of course a very pertinent question, but unfortunately no definite figure can yet be stated. Obviously the electronic equipment would have to be built as a shockproof unit, sealed in from the weather, and so constructed that it required no adjustment. It is the production cost of such a unit which cannot be accurately determined. For the purpose of discussion, the authors believe that a cost of $300 for the complete conversion of an average field duster would be a conservative one.

During the course of the summer of 1951, dusting work was done in the following crops: potatoes, onions, peas, celery, beans, and clover. The power-supply unit gave no trouble at all during this work, and with the exception of some minor difficulties with the design of insulators for the nozzle, this side of the equipment functioned without difficulty.

Obviously, the only real criterion of a duster's work is the efficiency with which it enables one to control pests and diseases, and in view of this it was hoped to demonstrate the superiority of electrostatic dusting in this respect during the field work. Unfortunately, however, with the exception of the first two named crops, no serious attacks were noted in the 1951 field tests in spite of the fact that in two cases certain plots in the test fields were dusted with as little as one-third of the normal dust application. In view of this, comparative results were obtained only from the potato work and from one of two onion fields treated.

In both these fields a significant improvement in crop yield was recorded on some of the plots where comparisons were made between charged and uncharged dust. As might be anticipated, the significant improvements were noted where the dust application levels were lowest. Although the biological results were few and not as conclusive as was hoped for, it was apparent to the eye in every case that more dust was recovered on the plant leaves when using charged dust, than when using uncharged dust, the two rates of application from the duster remaining the same.

To support the visual observations on the amount of dust recovered on the leaves, actual measurements were made on bean leaves after dusting had taken place. Lead arsenate dust was used and applied at the same known rate to the different plots, the only difference between the two treatments being that in one instance the dust was charged, and in the other it was not. The results of this test, which were calculated as a percentage, can be seen in the form of histograms in Fig. 8.

CONCLUSIONS

Speaking broadly, there are two definite advantages aimed for in using electrostatic dusting. First, a considerable saving in the applied quantity of dust required to afford protection to a particular crop, and, second, to give a better and more even coverage of the plant surfaces, which will naturally result in better protection for the plant. Basing an opinion on the work done to date, the authors believe that the dust requirement can be at least halved by the use of charged dust. The distribution of dust on the plant surfaces as observed during the summer of 1951 showed a slight but definite advantage from the charged dust, but in this respect it is thought that a greater improvement is attainable and work to that end is in progress.

In addition to these two main advantages, there are several subsidiary ones which appear to be well within reach, such as the elimination of the necessity for night dusting, and a reduced susceptibility to windy conditions.

Looking to other applications, it is worthy of mention that "electrostatic precipitation" is not restricted to dusts. Any small particle of matter can be thus precipitated, and, therefore, this method may find application with insecticidal fogs, aerosols, smokes, and sprays. (The insulation problem with aqueous sprays, however, will be very considerable.) A few preliminary tests have already been carried out in the laboratory with both fogs and smokes and these indicate the feasibility of this application.

Thus we have a method which shows signs of definite value to the farmer, but the reader should be left with the impression that the stage of development has not quite been reached where it can be said to have become a farmer tool. In addition to the economic aspects of its development, the durability of the equipment must be increased; and there are still a number of basic relationships such as optimum particle size for the dust and the optimum amperage input previously mentioned, which must be determined before the method can be considered ready to leave the research stage.

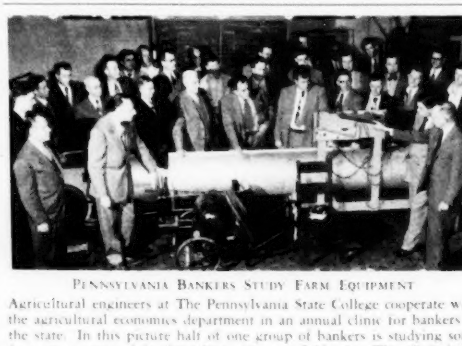
REFERENCES

1 Brooks, F. A. The Drifting of Poisonous Dusts Applied by Airplanes and Land Rigs. AGRICULTURAL ENGINEERING, 28 (June, 1947), pp. 233-239.

2 Hampe, P. Poudrage Electrostatique. *Revue de Viticulture*, 93 (1947), pp. 256-261.

3 Potts, S. F. Particle Size of Insecticides and Its Relation to Application, Distribution, and Deposit. *Journal of Economic Entomology*, 39 (1946), pp. 716-720.

4 Rosenblatt, P. and LaMer, V. K. Motion of a Particle in a Temperature Gradient; Thermal Repulsion as a Radiometer Phenomenon. *Physical Review*, 70 (September, 1946), pp. 385-395.



PENNSYLVANIA BANKERS STUDY FARM EQUIPMENT

Agricultural engineers at The Pennsylvania State College cooperate with the agricultural economics department in an annual clinic for bankers of the state. In this picture half of one group of bankers is studying some farm equipment while the others are on a field trip. The clinic helps bankers understand the operating-efficiency and production-capacity factors influencing security of their loans to farmers.

A Continuous Drying Process for Peanuts

By Vernon H. Baker, Buford M. Cannon, and James M. Stanley
ASSOCIATE MEMBERS ASAE MEMBER ASAE

THE drying and harvesting of the 220-million-dollar peanut crop in the southeastern and southwestern part of the United States is beset with unsolved problems which cause field damage, delays in marketing the crops, and unreasonably high labor requirements and production costs. In the harvesting in many areas, it is necessary to stack the peanuts and peanut-vine hay in the field from 4 to 8 weeks during which time they are subject to damage by weather, birds, and small animals. With the present method one man can plant and cultivate about three times as many peanuts as he can harvest. This creates a labor demand at harvest time which adds greatly to the cost of production. In an effort to surmount these obstacles, research is now in progress on the development of more efficient harvesting equipment (1, 2, 3)* whereby the nuts can be dug and picked in one or two operations. However, if such a method of harvesting is to be practical, a suitable method of curing the crop must also be developed to go along with it. With this situation in mind, research on drying peanuts and peanut hay has been instituted as a part of the cooperative forage-drying project of the Virginia Agricultural Experiment Station and the Division of Farm Electrification (BPISAE), U.S. Department of Agriculture. This paper is a progress report of three years' work. Other investigators (4, 5, 6, 7) have also conducted research on peanut drying.

Among the fundamental factors studied were the effects of temperature, relative humidity, and air flow, on the rate of drying, seed germination, and quality of the finished product. The resistance of air flow of dry unshelled Virginia Runner and Holland Jumbo Runner peanuts was determined. This information was used to assist in the design and to predict the operation of a continuous drier for peanuts. Preliminary investigations were conducted on processing peanut hay and harvesting the wet nuts.

Harvesting Machinery. Part of the equipment used to harvest peanuts for the tests reported in this paper is shown in Fig. 1. As the digger travels down the row, the blade (Fig. 1-1) raises the vines, nuts and dirt up over the shaking device (Figs. 1-2 and 3), where a portion of dirt is removed and then the mass of vines, nuts and remaining dirt fall to the ground. The large peanuts and soil types in the area of this test made digging difficult. In order to remove a high percentage of the nuts from the ground, it was necessary to use hand labor and pitchfork to shake the dirt from the nuts after they had been dug with the machine in Fig. 1. After the nuts were removed from the ground and the dirt shaken from them, they were allowed to wilt in the field until a moisture content of about 35 per cent wet basis was reached. Then a cylinder-type semicombine (Fig. 2) and a conventional stationary carding-type picker were used to remove the nuts from the vines. Tests have shown that the carding-type pickers are more effective for picking nuts from green vines and that they damaged fewer peanuts than cylinder-type pickers. The semicombine (Fig. 2) was towed through the field so that the nuts and vines could be forked into it.

FUNDAMENTAL DRYING STUDIES

Column Drier. In an effort to establish a relationship that exists between the amount of air used and the rate of drying and of the relationship between the temperature of the air used and the rate of drying, a total of 28 drying tests were made during two seasons, using the equipment in Fig. 3. The objectives of these tests were to formulate linear prediction drying equations and have quality tests made on the final dried peanuts so that the results could be used to predict the operating characteristics of a continuous drier for peanuts. Heated air at various air flows and temperatures (Table 1) was forced through approximately 50 lb of peanuts placed in a 9 x 42-in column suspended from springs (Fig. 3). It was possible to dry four columns of nuts during one test using a fixed air temperature with four different air velocities. Five thermocouples were placed in each column of nuts (bottom, 1/4, 1/2, 3/4, and top of column) in order to record the temperature at these points on a recording potentiometer as drying progressed.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Atlanta, Ga., February, 1952.

The authors: VERNON H. BAKER, associate agricultural engineer, Virginia Agricultural Experiment Station; BUFORD M. CANNON, formerly graduate fellow, agricultural engineering department, Virginia Polytechnic Institute; JAMES M. STANLEY, associate agricultural engineer, Division of Farm Electrification (BPISAE), U.S. Department of Agriculture (Blacksburg, Va.).

AUTHORS' NOTE: The authors acknowledge the contributions of the late E. T. Batten, associate agronomist and superintendent, Tidewater Field Station, Holland, Va., Dr. M. E. Terry, statistician, J. F. Eheart, associate chemist, Virginia Agricultural Experiment Station; Miss Laura Jane Harper, associate professor of home economics, Virginia Polytechnic Institute; Roy B. Davis, formerly associate agricultural engineer, Division of Farm Electrification, I. F. Reed, senior agricultural engineer, Division of Farm Machinery, and J. H. Beattie, formerly senior horticulturist, Division of Vegetable Crops, and Diseases (BPISAE), U.S. Department of Agriculture; Dr. A. C. Eaton, chief chemist, Planters Nut and Chocolate Co., Suffolk, Va., state and Nansemond County PMA officials.

*Numbers in parentheses refer to the appended references.

Fig. 1 (1) Blade of peanut digger. (2 and 3) After nuts are raised out of soil they pass over disk rollers and part of dirt is removed. (4) Conventional stacks of nuts in the field after the remainder of dirt from around them has been removed by shaking each bunch of nuts with a pitchfork

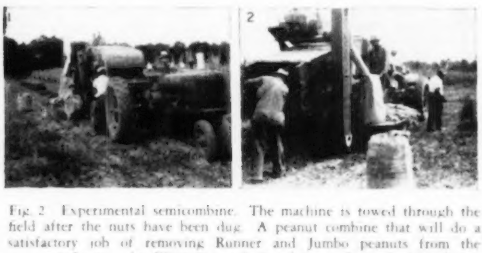


Fig. 2 Experimental semicombine. The machine is towed through the field after the nuts have been dug. A peanut combine that will do a satisfactory job of removing Runner and Jumbo peanuts from the windrow under Virginia conditions has not been developed

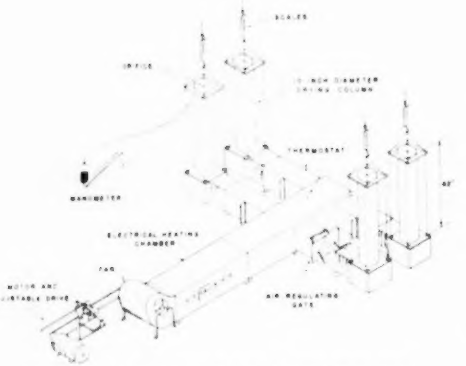


Fig. 3 The column drier used in fundamental drying studies

The weight loss was recorded at regular intervals during each test.

X and Y Values in Table 1. The X values shown in Table 1 were measured with the experimental apparatus, that is, X_{mc}, initial moisture content (dry basis), was determined by the oven method. X_t, average entering air temperature, was recorded with a thermocouple and a recording potentiometer. X_{rh} is the average relative humidity for entering air during the entire test and was obtained by entering the psychrometric chart with average wet-bulb and dry-bulb temperature readings that were recorded for each test. X_q, the amount of air used in each test, was measured with an orifice and manometer.

In an effort to obtain straight-line relationships between the various factors in the drying process, the following method of analysis was used to determine the Y values in Table 1. Since the X values could be measured directly, it was necessary to develop a technique for determining the Y values. Figs. 4 to 7 are shown for one test to present the method of determining these Y values. Due to faulty operation of the recording potentiometer during the second season, only 16 tests conducted during the first season have been analyzed in Table 1.

Y_1 in Table 1, the thickness of drying layer in inches, was secured by obtaining the difference in ordinate values of the trailing and leading drying edges (Fig. 4) after the equilibrium drying layer had been reached (Fig. 5), assuming adiabatic drying and neglecting heat of respiration. In the leading drying edge curve the time in hours that the temperatures at the different thermocouples located in the column of nuts began to rise was plotted as the abscissa and the depth of the peanuts at the different times was plotted as the ordinate. The trailing drying edge curve was obtained by plotting the time that the various thermocouples located in the column of nuts became equal to or approached the entering air temperature. All of the time values and temperature values were taken from the Brown potentiometer temperature recorder chart after the data on the recorder chart had been mechanically transferred to coordinate paper.

Y_2, the rate of movement of the trailing drying edge in inches per hour, is the slope of the trailing drying edge curve, Fig. 4. Y_3, time of departure of trailing drying edge, was obtained by reading the time value, where each trailing edge

TABLE 1. Fundamental Drying Data of the Small Peanut Samples Used in the Statistical Analysis for the Determination of the Prediction Equations

Y_1	Y_2	Y_3	Y_4	Y_5	X_{mc}	X_t	X_{rh}	X_q
Maximum thickness of drying layer, in	Rate of movement of trailing drying edge, in/hr	Time of departure of Y_2, hr	Time to reach one-half equilibrium weight, hr	Final MC bottom layer (dry basis)	Initial MC (dry basis)	Avg temp of entering air F	Avg RH of entering air	Air flow, cfm per sq ft
23.0	0.49	29.0	28.00	8.20	63.0	80.1	38	15
27.0	0.63	19.0	17.25	5.50	63.0	80.1	38	30
30.0	0.76	10.0	15.50	6.50	63.0	80.1	38	45
34.0	0.84	4.0	14.50	5.50	63.0	80.1	38	60
32.0	0.63	22.0	23.50	6.90	62.8	90.2	37	15
42.0	0.84	18.0	22.00	5.05	62.8	90.2	37	30
48.0	0.96	15.5	18.00	5.15	62.8	90.2	37	45
56.0	1.44	13.5	16.00	5.90	62.8	90.2	37	60
34.5	0.56	11.0	17.50	8.50	54.0	96.0	42	15
38.5	0.71	7.0	14.00	8.80	54.0	96.0	42	30
44.0	1.00	5.5	9.50	1.50	54.0	96.0	42	45
50.0	1.32	2.8	6.50	5.60	54.0	96.0	42	60
32.5	1.27	23.5	15.75	3.30	54.1	115.3	28	15
35.5	1.29	14.5	10.25	9.30	54.1	115.3	28	30
39.5	1.46	8.0	8.15	1.00	54.1	115.3	28	45
40.4	1.76	1.0	6.25	1.60	54.1	115.3	28	60

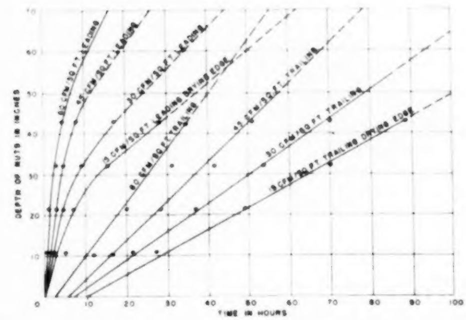


Fig. 4 Trailing and leading drying edges for column of nuts. Average entering air conditions: 96 F, RH (relative humidity) 42

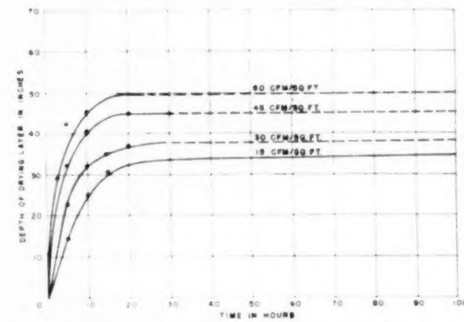


Fig. 5 Approximate thickness of drying layer Y_1. Taken from difference in ordinate values of the trailing and leading drying edges (Fig. 4)

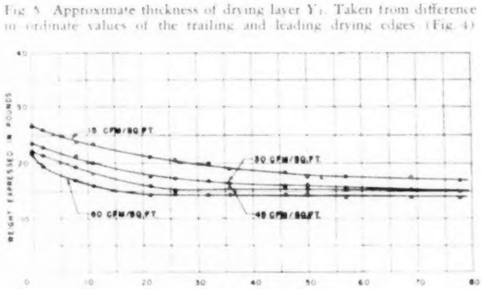


Fig. 6 Drying rate of column of nuts showing weight at any time T. Average entering air conditions: 96 F, RH 42

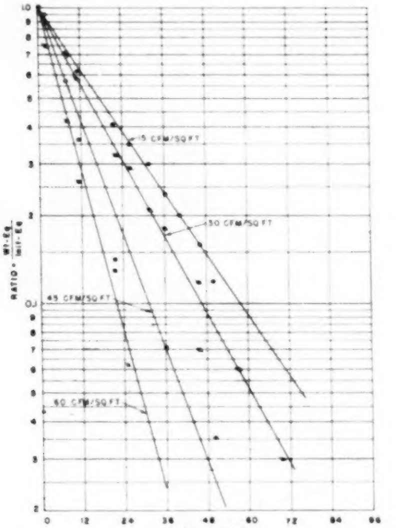


Fig. 7 Method of determining Y_4 which is time required for the weight of the peanuts in the entire column drier to go from a weight at any time T (Fig. 6) halfway to the equilibrium weight

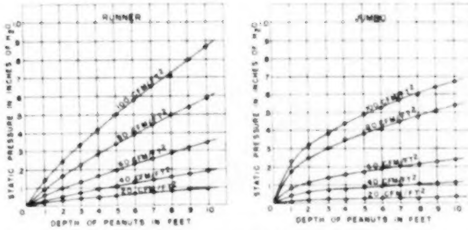


Fig. 8 The resistance of dry unshelled Virginia Runner and Holland Jumbo Runner peanuts to air flow

curve intersected the time axis on the depth of nut versus time curves (Fig. 4) of temperatures as each thermocouple point reached or approached the entering temperature, assuming that the thermocouple placed in the air surrounding a group of nuts actually measures the temperature of the nuts.

Y_4 is expressed in terms of hours and is the time required for the weight of the peanuts in the entire column drier to go from a weight at any time, t (Fig. 6) halfway to the equilibrium weight. In order to obtain a linear set of drying-rate graphs the data for each test was plotted on semilogarithmic graph paper where the abscissa was time and the ordinate was the weight ratio. The ratio is defined as the ratio of the weight of the nuts in the drier at the time of the observation minus the equilibrium weight, divided by the initial weight minus the equilibrium weight. The curves resulting when this information was plotted were straight lines on semilogarithmic graph paper in most every case (Fig. 7). Variations from a straight line might easily have been caused by a slight difference in interpolation of weight at the time of observation. The slope of these curves was determined for that portion of their length that they were straight or the falling drying rate period, and where it is felt that internal differences of moisture in the peanuts was a controlling factor. The surface moisture on the nuts was allowed to evaporate in the field before the nuts were picked; therefore, the constant drying rate period should not be a factor. Accepting this, the slope of the falling-rate curves should give some idea of the effect of the drying conditions on this portion of the drying process.

Y_5, the final moisture content of the bottom layer, dry basis, was determined by the oven method.

Prediction Equations for Column Drier Data. In order to make a rough evaluation of the relative importance of (X_{mc}, X_t, X_{rh}, X_q) upon (Y_1, Y_2, Y_3, Y_4, Y_5), the latter taken singly, the multiple regression technique (8) was used to find the best linear estimates of these effects. It might be noted that there are no theoretical conditions placed on the X's, i.e., they may take any value and these estimates are valid under the simple criterion of minimum variance (9). Following are the five regression equations:

$Y_1 = -468.363 + 3.35X_{mc} + 1.96X_t + 3.07X_{rh} + 0.323X_q$
$=$ thickness of drying layer in inches

$Y_2 = -3.941 + 0.028X_{mc} + 0.029X_t + 0.0013X_{rh} + 0.0130X_q$
$=$ rate of movement trailing drying edge in inches per hour

$Y_3 = -67.840 + 1.279X_{mc} + 0.189X_t - 0.101X_{rh} - 0.228X_q$
$=$ time of departure of trailing drying edge in hours

$Y_4 = -77.467 + 1.230X_{mc} + 0.168X_t + 0.365X_{rh} - 0.228X_q$
$=$ hours for entire mass of nuts to reach one-half equilibrium

$Y_5 = +12.485 - 0.032X_{mc} - 0.059X_t + 0.083X_{rh} - 0.066X_q$
$=$ final moisture content (dry basis) of bottom layer

When considering time of departure and hours to reach one-half equilibrium, note that the equations show very well, within limits of the number of observations, that three factors (X_{mc}, X_t, X_q) have the same over-all effect whereas the coefficient of RH (relative humidity) changes appreciably from positive to negative. The use of the equations will give "good" predictions within limits of the data. When the original data were substituted in the regression equations, the prediction values were reasonably accurate in most cases.

Discussion of Prediction Equations. *(a)* The relatively good fit of the equations to data seems to lend credence to the hypothesis of linearity of effects. *(b)* Accepting this, estimates of expected results for given conditions of moisture, etc., should be tested on further research and better estimates obtained. *(c)* The use of this statistical technique is relatively new in its engineering application. It does extract useful information when the main interest is in interpolation, close extrapolation, and prediction of performance. It may be that further study will suggest non-linear effects which also may be used in this technique to yield more reliable estimates. *(d)* In order to determine the value of this analysis for extrapolated conditions beyond the limits of this data, values for the different X's were substituted in the equations that would possibly be obtained in the field. If the Y value (with a given set of X's) comes out negative, this is an indication that the regression equations will not predict with this set of X values. *(e)* With these equations under a given set of conditions, approximate predictions of the maximum thickness of drying layer, the rate of movement of this drying layer, the time after drying started that the trailing drying edge would begin to move up through a column of nuts, and the final moisture content in the bottom layer could be determined.

The Resistance of Runner and Jumbo Peanuts to Air Flow. In order to obtain data regarding the resistance to air flow of dry unshelled Virginia Runner and Holland Jumbo Runner peanuts (Fig. 8), equipment consisting of a motor-driven fan, a horizontal air duct, and a vertical column for containing the peanuts was constructed. The vertical nut column with an area of 4 sq ft and height of 10 ft rested on a plenum chamber with a volume of 4 cu ft and was supported by a ½-in-mesh screen. Air velocities leaving the column of nuts were measured with an orifice and manometer. The static pressure in the plenum chamber beneath the column of nuts was also measured with a manometer.

CONTINUOUS DRIER

Work (10) at the Virginia Agricultural Experiment Station showed that it was not considered to be satisfactory to dry peanuts and vines together on a modified hay drier. After these tests it was decided to construct a continuous drier for

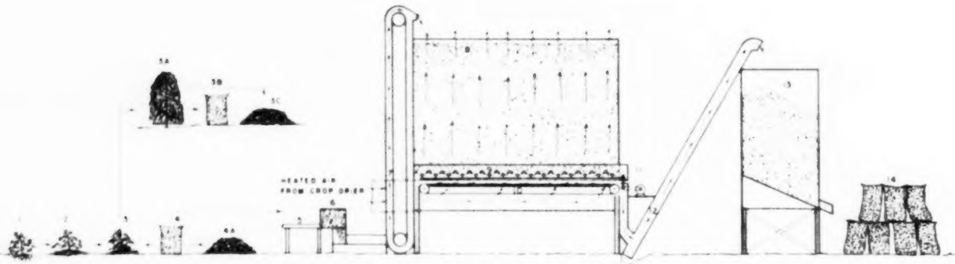


Fig. 9 Flow diagram of the peanut harvesting and drying process with cross section of continuous drier

the nuts which was developed at the Tidewater Field Station, Holland, Va.

This drier was built and first used during the 1949 season when three tests were made and a total of 35,836 lb (wet weight) of peanuts were cured. After being remodeled it was used during the 1950 season for three tests curing 34,836 lb (wet weight) of peanuts. Again in 1951 the equipment was used for two tests curing 16,071 lb (wet weight) of peanuts.

Experimental Peanut-Curing Process. The flow diagram (Fig. 9) illustrates the various steps in the harvesting and drying process as follows: 1, nuts in the ground before being dug; 2, nuts and vines after the nuts have been raised out of the ground with the digger; 3, nuts and vines after soil has been shaken from nuts with pitchfork; 3-A, conventional stack of nuts in the field; 3-B, field-cured nuts picked with conventional picker after they have remained in the field to cure from 4 to 8 weeks; 3-C, field-cured peanut hay; 4, wet nuts that have been picked with a conventional picker or semicombine; 4-A, wet hay that was baled and dried with supplemental heat. After the nuts were picked they were hauled to the loading platform, 5 and emptied into the hopper of the cleaning machine, 6. The cleaner removed peanut stems, some inferior nuts, cotton stalks, etc. The nuts were then fed into the vertical cup elevator, 7, then into the 8 x 12 x 6-ft drying compartment of the continuous drier, 8. Heated air from a crop drier was forced up through the nuts that rested on the shaking mechanism, 9. After a layer of nuts on the bottom of the drying compartment was dry, they were removed by passing them through the unloading shaking device, 9, onto the horizontal conveyor, 10. Then the nuts were moved to the inclined elevator, 12, and into the storage bin, 13. The nuts, 14, were then bagged for market.

Unloading Mechanism of Continuous Drier. One of the biggest problems encountered in the batch drier before an unloading mechanism was installed was that the bottom layer would always get drier than necessary before the top layer began to dry. In an effort to remedy this problem, a shaking device (9 in Fig. 9) was installed to unload the bottom layer of peanuts as they became dry. The unloading mechanism is similar to the grate in a furnace, and consists of a series of inverted V sections (see 10 in Fig. 9). A two-by-four was placed between each V section on pivot points at each end and was connected by a rocker arm to an oscillating mechanism through a gearshift and speed-reducing device driven by an electric motor. A total of 16 different speeds of the unloading mechanism was possible. With the four speeds used it was possible to obtain a capacity of 156, 231, 312, and 387 lb of dry nuts per hour from the drier. The distance between the rocker arms and the inverted V's was determined by trial and error, using a small prototype shaker. The same dimensions were used for both types of peanuts. When unloading was desired, the oscillating mechanism would rock slowly to allow peanuts to fall between the oscillating members and the edge of the V sections onto the horizontal conveyor which carries the nuts to the inclined elevator.

After installing the machine for cleaning the peanuts, before they entered the drier, the unloading mechanism performed much better since the trash and stems were not present. Some channeling was observed when the peanuts were unloaded allowing some wet peanuts to leave the drier prior to the desired time. This was caused by a slight difference in spacing of the component parts of the shaking device. It is felt that this could be corrected by a more accurately built unit.

Temperature and Air Flow. Heated air from a crop drier of the indirect type with pot burner was forced up through the nuts. By adjusting the electric float valve on the crop drier an average temperature between 85 and 90 F was obtained. The air velocity through the nuts was about 60 fpm. These values of temperature and air flow gave the best quality nuts in the fundamental drying studies.

Drying Compartment. The bin drying compartment, 8 x 12 x 6 ft. (Fig. 10) was designed to have a drying capacity approximately equal to that of the normal harvesting crew used for the experiment. More capacity is believed to be necessary before this type of drier will meet the peanut farmers' needs. The idea would be to load approximately two feet of nuts in the drier then start the air flow. After the bottom layer of nuts had been sufficiently dried, the oscillating mechanism could be started and the nuts unloaded. In this same period more nuts could be placed in the bin, thus making the drying process continuous or semicontinuous as conditions may warrant. By using the prediction equations previously discussed, for a given set of conditions, the depth that nuts should be placed in the drier for a higher percentage of drying efficiency can be calculated. With these same equations the rate of movement of the trailing drying edge can be determined which will assist in setting the speed of the shaking mechanism so that nuts may be removed at approximately the same rate that the trailing edge moves up through the column of nuts. Time of departure of a trailing drying edge will assist in determining the time lapse between first starting the machine and unloading the first batch of nuts. The final moisture content or equilibrium moisture content for a given set of conditions in the continuous drier may also be calculated. For example, suppose that $X_{mo} = 60$, $X_t = 80$, $X_{rh} = 40$, and $X_i = 30$. By substituting in the regression equations, Y_1 is found to be 30 in which is the thickness of the drying layer or the depth of nuts that should be placed in the drier for high efficient initial drying. With these same conditions $Y_2 =$ 0.50 iph, $Y_3 =$ 13.14 hr time departure of trailing drying edge.

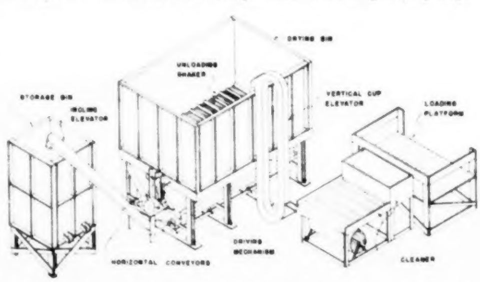


Fig. 10 General isometric sketch of experimental continuous drier, cleaner, elevators and storage bin

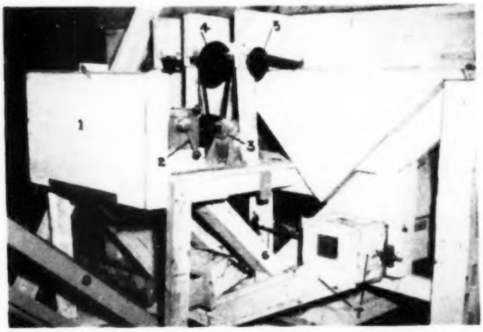


Fig. 11 View of front end of continuous drier: (1) driving electric motor behind guard (2) gearshift and speed reducers (4) Chain-and-sprocket drive for shaking mechanism (5) Eccentric and rocker arm (6) shaft for horizontal conveyor rollers (7) Horizontal conveyor with chute to inclined elevator

Y_4 = 17.53 hr for entire mass of nuts to reach one-half equilibrium, and Y_5 = 7.18 final moisture content per cent dry basis.

Cost of Drying in Experimental Drier. The cost of drying will vary considerably and will be affected by a number of factors such as weather conditions, initial moisture content, quantity of air used, temperature at which the drying is to be done, and management. Table 2 gives an approximate cost for each of the curing tests that have been made:

PEANUT HAY

Peanut hay is the only type of forage that many farmers have in the peanut-producing area. Since much of the hay is of such poor quality, due to the method of curing, it is spread back on the land. A large percentage of the leaves and color is lost by the present method of field curing resulting in a much lower grade of hay. By improving the hay that is now being saved and saving the hay which is now being lost, the income from peanuts could be markedly increased since peanut hay, when properly cured, is comparable in nutrient value to high-quality alfalfa hay.

Since peanuts are grown on sandy soil and sand has a tendency to grind down the teeth of animals that eat the hay, removing the sand from the hay is a problem. With proper harvesting techniques the majority of the sand can be kept out of the hay. The practice of removing the vines from peanuts in this area with a mower before digging has not proven satisfactory because running an extra machine through the field would damage the nuts themselves. In the harvesting process explained above the nuts were removed from the wet vines and then the vines were baled and cured with supplemental heat on a hay drier.

A bale of 35 to 40 per cent (wet basis) peanut hay is very dense and it is difficult to get air through each bale. Realizing that mold would possibly develop in the center of each bale, a number of bales were treated with a special sulfur-dioxide applicator during the 1950 season to determine if an application of this gas would prevent mold growth in the center of the bale. Bales so treated were dried together with untreated bales on a hay drier with an air velocity of 35 fpm at a temperature of 140 F. The results were encouraging in that mold growth was inhibited in the bales that were treated with sulfur dioxide, whereas a considerable amount of mold developed in the untreated bales. The hay from this test was not graded for quality; however, the loose hay that was dried with supplemental heat for the previous year (10) was graded U.S. No. 1 and No. 2, whereas the field-cured hay was graded U.S. No. 3.

TABLE 2

Year	Test	Peanuts processed Wet weight, lb	Peanuts processed Dry weight, lb	Moisture content of peanuts (WB) Wet	Moisture content of peanuts (WB) Dry	ΔT, deg F*	Drying efficiency, per cent†	Cost per 100 lb, cents‡
1949	1	9976	5220	39.2	7.4	9.1	31.8	66
	2	17024	8257	42.2	6.8	21.2	33.1	80
1950	1	11581	8010	34.2	9.6	12.9	23.1	33
	2	14651	7648	55.0	11.5	16.2	57.6	41
	3	8120	6089	17.8	10.4	24.6	13.8	25
1951	1	7709	5549	36.9	9.3	18.7	20.2	58
	2	8362	5334	46.4	9.3	19.6	43.0	41

*Temperature rise between air entering peanuts and ambient temperature.

†The method used in computing these efficiencies is explained in a thesis by Cannon (11).

‡Approximate costs based on oil priced at 13c per gal and electricity at 1.5c per kw-hr.

PEANUT QUALITY DETERMINATION

In determining the quality of the dried peanuts as well as the processed product, the following variables must be considered: (a) type of soil, (b) varieties, (c) time of planting, (d) date of digging, (e) time remaining in field after dug, (f) rate of drying, (g) method of processing, and (h) consistency of samplers.

Peanuts from the fundamental column-type drier and the continuous bin-type drier were processed into roasted nuts and peanut butter by the Division of Vegetable Crops and Diseases (BPISAE), U.S. Department of Agriculture, and by the Planters Nut and Chocolate Company for taste quality and rancidity determinations. Duplicate samples of the dried peanuts were subjected to germination, skin slippage, and breakage tests. Rancidity tests on the peanut butter and roasted nuts were conducted by chemists of the Virginia Agricultural Experiment Station. Processing tests, shelling and grading, were conducted by the Greensville Peanut Company, Emporia, Va.

Taste-Test Peanut Butter and Roasted Nuts. Taste is one of the most important factors in the quality of peanuts and peanut butter. It is one which has no standards for judging since every judge may have a different sense of taste. The requisites for a good taste judge include the ability to differentiate in taste, to determine which taste is the best, and to be consistent in judgment. Methods of choosing and eliminating judges have been studied and reported in a thesis by Lombardi (12).

A taste panel was established by the home economics department of the Virginia Polytechnic Institute under the supervision of Miss Laura Jane Harper, associate professor of home economics, for the purpose of judging the roasted nuts and the peanut butter processed from each sample (8). The peanut butter was scored on the basis of 100 per cent with taste constituting 60 per cent, texture 20 per cent, spreadability 10 per cent and color 10 per cent. The roasted nuts were scored as follows: Taste 60 per cent, crispness 20 per cent, color 10 per cent, and odor 10 per cent. Results from these taste tests indicate that peanuts can be dried artificially and still retain a palatable flavor. Best results were obtained using a temperature of 85 to 90 F and an air velocity of 45 to 60 fpm.

Rancidity of Peanut Butter and Roasted Nuts. The "Kreis" and "peroxide" tests were used in an effort to determine the effect of temperature and air flow on the rancidity of the processed peanuts for the second season. In every case the results were negative for the Kreis test, indicating no rancidity. There does not seem to be any correlation between the temperature and the amount of air and the peroxide values obtained.

Germination. In each germination test a batch of 100 kernels, which had been hand-shelled, were wrapped in a paper towel and placed in a damp place. Duplicate samples were made wherever possible. These samples were covered with burlap to keep them dark and to hold moisture which was applied as needed. They were inspected intermittently and the number of germinated kernels was recorded with the results being expressed on a percentage basis. A field-cured sample was included and was used as the basis for comparison in this as well as all other quality tests that were made. From the data obtained there seems to be no indication that the temperatures used—80 to 120 F—affected the germination. Results of the germination tests also indicate the peanuts are not affected by air flow as long as enough air is passed

through them to prohibit mold. However, at an air velocity of 15 fpm, the nuts mold before drying, and germination is retarded by this action. Using the same type peanuts, better germination was obtained in the continuous drier than with the field-cured samples. This cannot be considered conclusive, since results were so varied; however, it can be the criterion for further studies.

Skin Slippage and Breakage. This has been the most significant problem encountered while drying peanuts with supplemental heat. Tests conducted by Dr. Eaton and Mr. Beattie indicated that the breakage of the kernels and skin slippage increased as the drying rate was accelerated. The red skin around each kernel serves as a protective covering, and when this covering is destroyed, the kernel tends to absorb moisture and odors which are detrimental to its quality. If this skin is destroyed to an extent that will allow the two halves of the kernel to separate the over-all quality will be lowered, because these half kernels will pass through the grading equipment with kernels of a lower grade, rather than with the larger kernels where they would go if the halves remained together. This is very important in the Virginia and North Carolina areas since the crop is grown primarily for a market that places a premium on the large kernels. The samples that were processed from the 1951 curing tests were found to have a larger percentage of broken nuts than was desired.

A physiological study of the peanut, during the drying period, was started during the 1951 curing season. This was in cooperation with the botany and statistics departments of the Virginia Polytechnic Institute. Samples were collected from eight curing tests, each receiving a different treatment of temperature and air flow. Temperatures of 90.5 and 107.4 F and air flows of 15, 30, 45 and 60 cfm were used. The samples were fixed in a killing solution. Final findings of the studies conducted by the botanist on these samples will be reported in a future progress report.

REFERENCES

1 Giles, G. W., "Peanut Mechanization in North Carolina." Proceedings of Association of Southern Agricultural Workers, p. 41, Biloxi, Miss., February, 1950.

2 Stokes, C. M., and Reed, I. F., "Mechanization of Peanut Harvesting in Alabama." AGRICULTURAL ENGINEERING, April, 1950.

3 Kenney, W. D., and Shepherd, J. L., "Development of a Peanut Combine Harvester." Mimeographed report, Georgia Coastal Plains Experiment Station, Tifton, Ga., 1950.

4 Sorenson, J. W., et al, "Harvesting and Drying Peanuts in Texas", Progress Report No. 1124, Texas Agricultural Experiment Station, College Station, June, 1948.

5 Shepherd, J. L., and Kenney, W. D., "Some Results in Peanut Harvesting and Curing Studies." Mimeographed report, Georgia Coastal Plains Experiment Station, Tifton, Ga., 1949.

6 Teter, N. C., "Peanut Drying." Paper presented before Southeast Section of American Society of Agricultural Engineers, Biloxi, Miss., February, 1950.

7 Butt, J. L., and Kummer, F. A., "Artificial Curing of Peanuts in Alabama." AGRICULTURAL ENGINEERING, January, 1951.

8 Kendall, M. G., *Advanced Statistical Theory*, vol. 2, Griffin Press, London, 1946.

9 Cramer, H., *Mathematical Methods of Statistics*, Princeton University Press, p. 497, 1946.

10 "Peanut Harvesting and Drying Research 1947-48-49." Virginia Agricultural Experiment Station Bulletin No. 439, June, 1950.

11 Cannon, B. M., *"The Development of a Continuous Peanut Drier."* Thesis for degree of master of science, Virginia Polytechnic Institute, December, 1951.

12 Lombardi, G. J., "The Sequential Selection of Judges for Organaleptic Testing." Thesis for degree of master of science, Virginia Polytechnic Institute, June, 1951.

The Kinematics of Tractor Hitches

(Continued from page 346)

same tractors with trailing wheel-supported chisels. The wheels on a trailing chisel must carry heavy soil-reaction loads. These wheel loads subtract from the useful power of the tractor, while with the mounted chisel the soil reaction assists in producing traction.

The foregoing examples indicate some of the versatility of the three-link-type hitch. However, the infinitely variable fixed-link hitch has not been explored to determine its performance during pitching. Fig. 10 shows the lister pitched up and down the same as Fig. 6, namely, 4 in from the level position of the rear lower link hitch pin. When pitched down, *P* on the line of draft falls below *Q*, hence the hitch is free and *P* will attempt to intersect *Q*. The frame of the lister is tilted forward to the immediate ground surface; therefore, the soil reaction *V* will tend to increase and steepen the slope of the line of draft. This plus the convergence of *P* and *Q* will rapidly bring a state of equilibrium without the lister bases shallowing any great amount. With the implement pitched up, *P'* is well above *Q'* so that the hitch remains fixed and fully responsive to any changes of the controlling mechanism.

Thus far only the kinematics of hitches in the vertical longitudinal plane have been considered. Fig. 11 is a plan view of a three-link hitch and portrays the kinematics of the linkage when the implement yaws in respect to the tractor.

In the straightaway position the instantaneous swing point of the hitch M_1 falls on the center line of the tractor. As the implement yaws to the left, the instantaneous swing point moves to the right as indicated by M_2 and M_3. In the particular linkage shown, the line of draft passes very close to the center of the rear axle so that the yaw would have small effect upon the steering of the tractor. The effect the yaw would have is equivalent to that of a swinging drawbar pivoted slightly to the rear of the rear-axle center line. By changing the length of the links, their converging angle, etc., almost any desired steering reaction may be obtained with the yawing of the implement.

The foregoing examples and their analyses are intended to clarify to some degree the tractor reactions resulting from various implement hitches. From this study the following conclusions may be drawn:

1 The position of the implement relative to the tractor, and not the type of hitch, determines the weight transferred to the rear wheels of the tractor.

2 Weight transfer within the tractor depends upon the line of draft, its angle and magnitude, and its relationship to point *C*.

3 The vertical component of *P* is added to the total downward forces of the tractor, and the distribution of this load is determined by the point of application of *P* to the tractor.

4 In a three-link type of hitch the length of the links and the angles formed by them, in both the horizontal and vertical planes, have great effect upon the implement performance secured with the hitch.

5 The tractor-mounted implement with a steep line of draft shows to greatest advantage in the field because of the greater weight transfer.

6 The free-link type of hitch is sensitive to changes in the line of draft, whereas the variable fixed-link type of hitch is affected by line of draft changes only when the line of draft falls below the instantaneous pivot point.

7 The maximum working depth of an implement hitched to a tractor with an infinitely variable fixed-link hitch is determined by the intersection of the force *P* and the instantaneous pivot point *Q*.

Heating Water with the Heat Pump

By Andrew Hustrulid and H. A. Cloud
MEMBER ASAE ASSOC. MEMBER ASAE

USE of the heat-pump principle is gaining popularity as a means of heating water for domestic use and in some of the milder climates of the United States for space heating. An excellent discussion of the heat pump as a space heater as well as the basic principles of the heat pump is given by Penrod (1)*. The practical application of the heat pump as a domestic water heater and the development of a packaged unit is discussed by Freyder (2) and Ruff (3). The principal heat source used in the packaged heat-pump water heater has been the basement air of the home. Heat sources used in other heat-pump installations have included well water, lake water, outside air and the soil. This paper will discuss the results obtained when the home freezer box was used as the heat source for a water-tempering system in which the refrigerating unit on the freezing cabinet delivered the heat directly to the water-tempering tank. Preliminary experiments carried on by Hajima Ota (8) were used as a forerunner to the results reported in this paper.

Experimental Setup. Three series of experiments were conducted to determine the operating characteristics of the heat pump for this purpose under varying conditions. The first series was conducted using a ½-hp water-cooled condensing unit in which the water from the tempering tank was pumped through the counter-flow condenser as a means of picking up the liberated heat. The second series was conducted using the same refrigerating unit but placing the condenser directly in the tempering tank instead of using the counter-flow condenser. Schematic diagrams of these setups are shown on the graphs summarizing the results of these experiments.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Rural Electric Division. Authorized for publication as Scientific Journal Series Paper 2801 of the Minnesota Agricultural Experiment Station.

The authors: ANDREW HUSTRULID and H. A. CLOUD, respectively, professor and instructor of agricultural engineering, University of Minnesota, University Farm, St. Paul.

*Numbers in parentheses refer to appended references.

In the third series a ½-hp hermetically sealed refrigerating unit was completely rebuilt in such a manner as to allow placement of the complete unit in the tempering tank. The arrangement of the equipment as used in this third series of experiments is shown in Fig. 1. The completed unit ready to be placed into the tempering tank is shown in Fig. 2. These figures show that the complete unit is attached to the cover of the tank and is completely free from the tank itself. This is to allow for complete freedom in handling the refrigerating unit itself. The cold-water supply entered the tempering tank at the bottom and the warm-water discharge pipe left the tank at the top.

Measurements and controls for the experiment were set up to be as nearly automatic as possible. The discharge from the tempering tank was controlled by a thermostatically operated solenoid valve. The discharge and supply water temperatures, along with the cold box and ambient temperatures, were recorded on a micromax temperature recorder. Kilowatt-hour meters were used to record the input to the compressor motor and the artificial heat input to the cold box. A water meter was used to record the total amount of water passing through the tempering tank. The necessary data which were taken during the tests included: (a) discharge-water temperature, (b) supply-water temperature, (c) kilowatt-hour input to the compressor motor, (d) heat input to the cold box, (e) average evaporating temperature, (f) box temperatures, (g) amount of water discharged, (h) total time of test, and (i) running time of compressor. The tests were started immediately following the discharge of the tank and stopped at the same point after a series of discharges.

Results. The "performance factor" will be used in discussing the comparative results of the experiments. It is defined as a ratio of the total heat absorbed by the water in the tempering tank to the equivalent heat input to the compressor motor. The coefficient of performance referred to is a ratio of the total heat removed from the cold box to the equivalent heat input to the compressor motor. In graphically showing the results of these experiments, the performance factor is plotted against the water-discharge temperatures for the various conditions of the three setups.

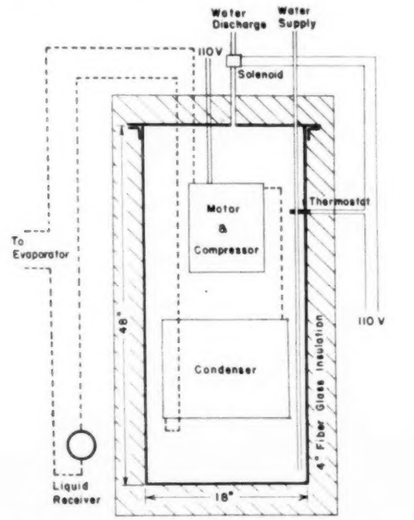


Fig. 1 Diagram of the submerged unit as used in the experiment

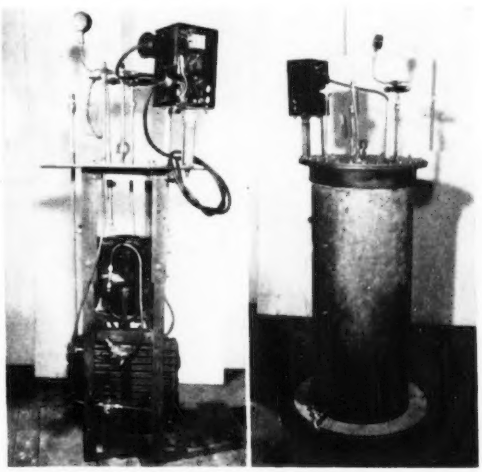


Fig. 2 Submerged unit (*left*) ready for placement in the tempering tank and (*right*) assembled in the tempering tank

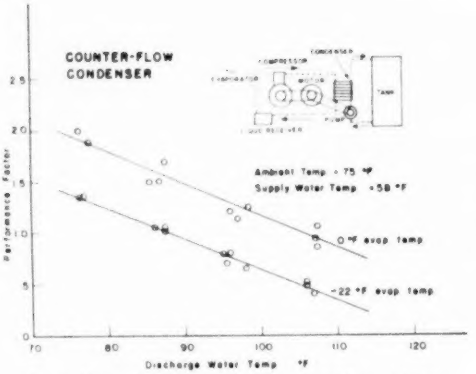


Fig. 3 The results of the tests using the counter-flow condenser

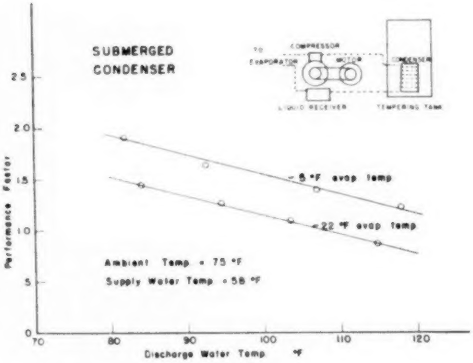


Fig. 4 The results of the tests on the submerged condenser

Fig. 3 shows the results of the first setup in which the heat was picked up by circulating water from the tempering tank through the counter-flow condenser. The upper curve shows the results when the evaporating temperature in the plates was approximately 0 F, while the lower curve represents an evaporating temperature of from −20 to −25 F. The schematic diagram in the upper right-hand corner of the figure shows the experimental arrangement of this setup.

Fig. 4 shows the results of the second setup in which the condenser was placed directly in the tempering tank. A schematic diagram of the experimental setup is again shown on the chart of the graphical results. The upper curve represents an evaporating temperature of approximately −5 F while the lower curve represents the result of an evaporating temperature of approximately −22 F. The evaporating temperature normally encountered in domestic freezing units will usually fall somewhere between these two values.

Fig. 5 shows the results of the tests run on the submerged hermetically sealed motor-compressor unit. Three series of tests were run on this setup, at evaporating temperatures of −4, −18, and −33 F. The three curves formed by the solid lines are the results of plotting performance factors against discharge-water temperatures while the curves formed by the dotted lines are the coefficient of performance of the refrigerating unit plotted against the discharge temperature. These sets of curves show that the performance factor for a given discharge-water temperature and evaporating temperature was approximately one greater than the over-all coefficient of performance of the refrigerating unit for the same conditions. In other words, by this arrangement the total heat absorbed from the heat source plus the equivalent heat input to the compressor motor is delivered as useful heat to the water in the tempering tank. This should be expected since the only source of heat loss would be through the insulation of the tempering tank and the liquid refrigerant lines, a small amount. All of these tests were run at a heat load, supplied by lamps, in the cold box such as would require the compressor to run from two-thirds to three-fourths of the time. The effect of less heat load and consequently lower compressor running time is shown by a curve on this same Fig. 5, which shows the results obtained when the compressor running time was cut to approximately 45 per cent. Since the cold-water inlet to the tempering tank was at the bottom and the warm-water discharge at the top, the average temperature of the water in the tank over the complete time of the test was considerably lower than the discharge temperature. This explains the crossing of the two curves since the tank lost heat to the room when the average water temperature in the tank was above room temperature, and gained heat when the average temperature was below room temperature.

Table 1 shows typical test data taken on these experiments.

TABLE 1

Total time of test hr min	Running time of comp hr min	Total disch. (gal)	Average disch temp., F	Average supply temp., F	Kw-hr input to motor	Kw-hr input to cold box	Room temp., F
21 50	16 35	257.0	85.8	60.0	6.90	8.14	70-74
18 00	14 25	153.0	98.0	60.4	6.26	6.88	70-75
18 20	15 30	121.9	108.5	59.0	7.00	7.00	69-74
18 00	15 40	104.5	118.8	61.9	7.47	6.82	69-76

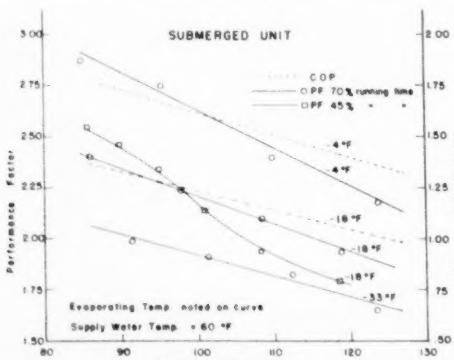


Fig. 5 The results of the tests on the submerged unit

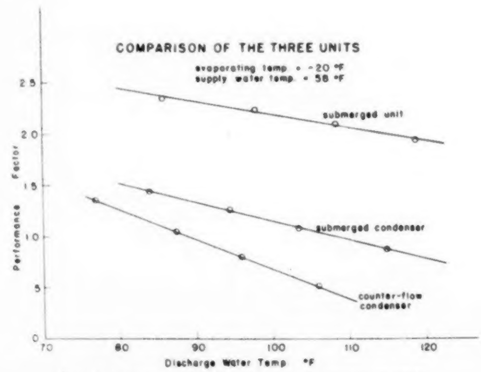


Fig. 6 A comparison of the three water-tempering units

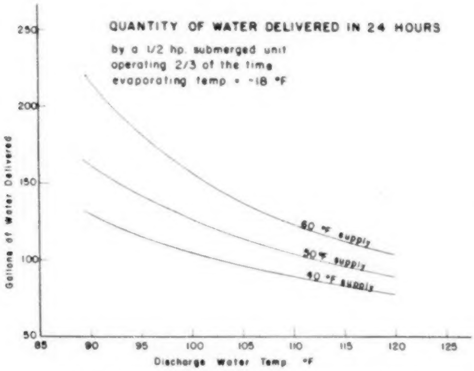


Fig. 7 Water-tempering capacity of the submerged unit

The data in this table is taken from the tests on the submerged unit operating at an evaporating temperature of −18 F.

Fig. 6 shows the comparative performance factors obtained from the three setups. These results show that the submerged unit offers the greatest possibilities for future use of this type of development. The large heat losses at the motor, compressor head, etc., encountered in the first two setups are completely eliminated in the submerged unit in which these radiated losses are absorbed by the water in the tempering tank.

DISCUSSION

A water-tempering system of the type described in this paper would probably be practical if the operating performance factor were 2 or greater. From the results obtained from these experiments the only arrangement which is proved on this basis is the submerged hermetically sealed unit. With a performance factor equal to 2 this tempering unit, in addition to operating the home-freezing unit, is heating water just as economically as a conventional electric water heater using off-peak electrical rates. The results show that this ½-hp unit gave a performance factor of 2 in heating water from 60 to 115 F at an evaporating temperature of −18 F. All the water discharged from the unit in giving these results was at this higher temperature. In a domestic setup during periods of relatively high water consumption this condition would not be true, and the performance factor would consequently be increased as a result of the lowered condensing temperature. Fig. 7 shows the water-heating capacity of this unit operating at an evaporating temperature of −18 F and running two-thirds of the time. One very noticeable condition of the submerged unit is its extreme quietness during operation.

An improvement over this experimental arrangement would be to have the complete motor-compressor, condenser, and liquid receiver unit at the bottom of the tempering tank. At this position the entire unit would be in the coldest water in the tank and would benefit from the cold water inlet at the bottom of the tank. Starting with only the circular arranged motor-compressor unit, a copper tube condenser could be coiled around the unit with a circular liquid refrigerant receiver directly under the condenser. This compact unit would then be placed at the bottom of a 50 to 80-gal tempering tank. The complete unit could be mounted on a base which would also serve as the bottom of the tempering tank. The refrigerant lines and power leads to the motor would then leave the tank through this base, giving a very compact unit.

In order to prevent damage to the unit caused by high head pressures during periods of no water consumption, a safety waste valve would have to be installed. This could be a thermostatically operated solenoid valve which would waste water during these periods in order to keep the head pressure of the unit at a safe level. Under normal operating conditions from day to day with a properly balanced unit, there would be no water wasted by this safety action. To obtain the most satisfactory and economical operating conditions, the size of the tempering tank, the size of the refrigerating unit, and the amount of insulation on the freezing unit should be properly balanced.

REFERENCES

1 Penrod, E. B. Progress in Heat Pump Engineering. *Physics Today*, vol. 5, February, 1952.

2 Freyder, G. G. Domestic Water Heater Employs Heat Pump Principle. *Electric Light and Power*, vol. 29, August, 1951.

3 Ruff, A. W. The heat pump water heater. *Refrigerating Engineering*, vol. 59:153-154.

4 Newton, Alwin B. Practical Application of the Heat Pump. *Refrigerating Engineering*, vol. 59:145-147, February, 1951.

5 Kemler, E. N., Oglesby, S., and Pease, W. C. The Heat Pump—Past, Present, and Future. *Refrigerating Engineering*, vol. 55, April, 1947.

6 Pappas, S. L., Thomas, A. L., O'Brian, F. R. Capacity and Performance Tests on Three Air to Air Heat Pumps. Southern Research Institute, Birmingham, Ala.

7 Freberg, C. R., Pappas, S. L., O'Brian, F. R. The Heat Pump Guide. Southern Research Institute, Birmingham, Ala.

8 Ota, Hajima. Supplementary Water Heating with Domestic Freezer Compressor, Master's thesis, University of Minnesota, December, 1950.

Quick Method of Casehardening Steel

By C. N. Johnston
MEMBER ASAE

SEVERAL years ago the writer noted, after cutting steel sheets with an electric arc using a carbon electrode, that the edges of the cut had become so hard as to be completely unworkable with files or even hardened lathe tools. The idea suggested lay dormant till an occasion arose to caseharden the tapered cutting edge of a pointed tool, when the use of the carbon arc for that purpose was tried. The results of the test, as suggested by the previous experience with the carbon arc, were excellent. It was necessary only to keep the current flow down and the arc short and in constant travel to produce a hard surface. One objection to the surface was that it was roughened some during the process. This problem was solved, after some experimentation, in the following manner:

It was thought that the arc was necessary, so various methods of vibrating the object to be hardened, or the carbon rod, were tried to keep the arc short while at the same time the work or the rod moved to keep the temperatures on the work surface down. These procedures improved the surface texture on the hardened area, but only partially in the direction of perfection. It was noted that, when the carbon actually rubbed the surface to be hardened, while there was no arc, the hardening was effective and with a minimum of disturbance to the surface. Additional trials wherein the carbon or the work was moved while the carbon contacted the work firmly produced the best case on a polished surface when the least disturbance to the polish was desired.

The writer believes this process is new, takes credit for having stumbled onto it, and passes it on to all who may wish to use it.

For those who may wish to try the method, currents as low as 30 amp d-c or a-c will produce a substantial case on an area of 3 to 6 sq in in 1 to 3 min. Higher current flows up to 200 amp have been used with success. The carbon rods used were the common arc light variety from about ⅜ to ½ in diameter and were tapered slightly to a flat-faced chisel edge.

The writer wishes to express appreciation to James A. Worrall, mechanic in our laboratory, who gave of his time while we experimented on this process.

The author: C. N. JOHNSTON is professor of irrigation, University of California, Davis.

Agricultural Aviation

By E. W. Lehmann
FELLOW ASAE

As CHAIRMAN of the Committee on Agricultural Aviation of the American Society of Agricultural Engineers, I have brought together certain facts from the different agricultural colleges and experiment stations on the present status of agricultural aviation. The opportunities for agricultural engineers in this field is still limited.

The greatest interest in agricultural aviation is in those states where the use of the airplane has had wide acceptance—in the extreme West, California, and in the Southwest, particularly in Texas and Oklahoma. The airplane is being used in the Middle West in such operations as insect control, weed control, the application of fertilizer, to a limited extent the application of seeds, particularly for cover crops. The agricultural engineer has the same interest in agricultural aviation as in other types of farm machines and implements used in agricultural production, i.e., for improving production economy, increased yields, and improved quality of products.

Agricultural engineers are interested in the programs of Flying Farmer groups, which is one of the largest groups of private plane owners and operators in the country. The Flying Farmers were organized as a state group at Stillwater, Okla., in 1944, and the National Flying Farmers Association was organized in 1946 with headquarters also at Stillwater. It is estimated that there are now approximately 20,000 Flying Farmers in the United States. This group has played an important part in starting the research that is reported in the accompanying paper by Fred E. Wieck.

The agricultural engineering departments of the state colleges are also interested in the programs of custom operators, who use the airplane in insect, weed, and brush control, and for other uses such as fertilizer and seed application for which the plane has been found to be effective and economical in operation. They have cooperated in planning educational programs for this group, as well as for Flying Farmers. They have used the airplane in extension work in making soil conservation observation flights.

Agricultural engineers are likewise interested in research relating to the airplane, and for many years certain members of ASAE, including Frank Irons and O. K. Hedden, have been actively engaged in research in this field. This program has been one of fundamental research, as well as research on equipment development. As a result of this work, special equipment in the form of attachments for distributing various materials has been developed.

There are opportunities for agricultural engineers in each of these phases of work, i.e., in educational programs, in research, and as custom operators. At the present time some agricultural engineers, doing professional engineering, have a service organization which includes the use of the airplane in doing certain jobs, including insect, weed and brush control, and fertilizing and seeding. In conservation work the airplane has been used in mapping, which has contributed to the soil conservation planning programs.

The Institute of Aviation at the University of Illinois has equipped two airplanes and a helicopter for experimental agricultural use. The agricultural engineer is in position either through research or experience to provide data and information to the aeronautical engineers to be used in the design and development of applicating equipment. They are thoroughly qualified to solve those phases of the problem that make the plane an effective mobile farm power unit. Spray patterns, desired rates of application, loading requirements, and a lot of other data must necessarily be supplied to the aeronautical engineer for use in the development of new or in the improvement of existing attachments for applying and distributing materials. Some of the fundamental problems determining the effectiveness of airplane spraying, the relation of particle size to drift, are being studied by agricultural engineers.

It was reported from California that about five million acres of farm land will be treated by the aircraft, including spraying, dusting, aerosoling, in 1951. It was stated that in 1949 at least 2,117,000 acres of land were treated which shows that the area has more than doubled over a 2-year period. The opportunities outlined for agricultural engineers in this area are limited at present to research personnel; the present need is for pilots and airplane mechanics.

The various types of treatment on agricultural areas in Kansas showed an increase from 419,455 acres in 1948 to 918,979 in 1949. It is estimated that the figures for 1950 would be in excess of 1,000,000 acres to be sprayed. There have been similar increases in other states.

To further this work the U.S. Department of Agriculture has issued information leaflets, on this subject. Series No. 87 by D. A. Isler, agricultural engineer, was issued in August, 1948, on "Spray Equipment for Stearman N2S Airplane." This unit has been used and adapted to this type of plane by many commercial custom operators throughout the country.

The agricultural aviation work at Ohio State University, reported by R. D. Barden of the department of agricultural engineering, as being carried out in the spring of 1951, included: (1) a test program working with T. H. Parks, entomologist in the control of spittle bugs; (2) work with producers of chemicals in the control of red spider in ornamental evergreens; (3) application of liquid fertilizers as a top-dressing for wheat; (4) joint application of seeding and top-dressing of fertilizers at periods of the year when it is impossible to get around with ground equipment; (5) work with the state highway department on the problem of deicing highways; (6) work with the Ohio Agricultural Experiment Station in control of sawfly in evergreens; (7) work with the manufacturers in the development of sprayers and dusters for the agricultural plane; (8) work with the Ohio Agricultural Experiment Station on test program on control of corn borer (ground and air equipment were compared in this test); (9) work with the Experiment Station on diseases and insect control in canning tomatoes; (10) work with the rural electric cooperatives in southwestern Ohio on brush control on right-of-ways (work is under way to develop a plane and distribution equipment especially adapted to this kind of work and the program has attracted widespread interest, and (11) at a recent meeting of the legislature a request of the state board of aviation was granted for an appropriation to be used in agricultural aviation research.

While the greatest advances in agricultural aviation have taken place since World War II, the use of the airplane in agriculture is not a new activity. It is reported that the first aerial dusting was tried in 1918 near Reno, Nev., by George G. Schweiss. Following World War I, many pilots who were experienced in flying became stunt fliers and operators of dusting equipment. Planes used for dusting were not as well suited as they should be, and the same is true of a lot of surplus planes used in agricultural aviation work following World War II. The need for improving this situation and making possible a better agricultural plane has prompted the USDA and some state agricultural experiment stations to devote attention to this problem. The only station which has an extensive program is the Texas agricultural experiment station, a program which is conducted in cooperation with the Flying Farmers, the Civil Aeronautics Administration, and the U.S. Department of Agriculture. O. K. Hedden of the Toledo laboratory was assigned to the Agricultural Aviation Project at College Station, Texas, to work on the dispensing equipment for use with the new aircraft developed there under the direction of Fred E. Wieck.

Introductory statement made at a special session on agricultural aviation at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951.

The author: E. W. LEHMANN, head, agricultural engineering department, University of Illinois, Urbana.

Development of an Agricultural Airplane

By Fred E. Weick

A PROGRAM of research on agricultural aviation problems is under way at the Personal Aircraft Research Center of the A. and M. College of Texas. Realizing the need for development in the fast-growing field of dusting and spraying by airplane, the National Flying Farmers' Association initiated the project in cooperation with the Civil Aeronautics Administration, the U.S. Department of Agriculture, and the A. and M. College of Texas System.

The first step was to design, construct, and develop an experimental airplane especially for dusting, spraying, seeding, and fertilizing, together with initial steps in the development of improved dispersing equipment. It appears that there will be a fertile field for research in the measurement and improvement of distribution for a number of years ahead. The second stage of the project involves the distribution equipment.

Information on the characteristics most desired in dusting and spraying airplanes has been obtained from the dusting and spraying operators, partly by personal interview but mostly from a CAA survey which covered the entire country.

Since the field covers too large a range to be handled by a single type of airplane, a plane of medium size has been selected for the experiment with the thought that it might be adequate for a substantial portion of the work. Any proven satisfactory developments can, of course, be applied to larger and smaller airplanes.

An airplane, designated the Ag-1, has been designed and constructed under a CAA contract which became effective on December 7, 1949. The project has been aided by personnel assigned for various periods by the CAA, USDA, two airplane manufacturers, and the A. and M. College of Texas. Also, many important parts including the engine, propeller, landing gear, and seat have been contributed by their manufacturers.

The Ag-1 airplane has been completed, except for dusting and spraying equipment, and was first flown on December 1, 1950. During the months following it underwent a succession of flight tests and minor modifications and refinements. Then from June through October, 1951, it was taken on a demonstration tour by the CAA. This tour covered over one-half of the United States and many different agricultural areas. More than 500 pilots, mainly operators of dusting and spraying airplanes, were given an opportunity to fly and evaluate the airplane, and a study of the comments will be used as a guide for possible further modifications. The airplane has now been returned to College Station for further development, particularly with regard to the dispersing equipment.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951.

The author: FRED E. WEICK, Personal Aircraft Research Center, A. & M. College of Texas.

LOADS

The suggested amount of dust or spray load to be carried varied from 400 to 2000 lb, most of the suggestions ranging from 600 to 1200 lb. The airplane is designed to carry a normal maximum dust or spray load of 800 lb with provisions for overloading to 1200 lb under unusually favorable take-off and operating conditions. The airplane has been designed to take any promising form of dispersing equipment at least for experimental development. Separate dust hopper and spray tanks are provided so that the operation can be switched from dusting to spraying at a moment's notice when conditions make this desirable, which is often the case. The first installations of dusting and spraying equipment followed the suggestions of O. K. Hedden of the U.S. Department of Agriculture.

Distribution Means. The usual present distribution from a venturi or spreader from a single central hopper is not uniform because it is too concentrated in the center. It is desirable that improved dispersing equipment, probably including means for metering, be developed further to improve the distribution. It is planned to measure the distribution pattern obtained with the best available present-type venturis and spreaders, and to attempt to improve them. A 27-cu-ft hopper has been provided in the fuselage for this part of the program. In addition, space has been provided in the outer wing panels for the same total hopper capacity in case it appears desirable for a more uniform or a wider distribution to disperse the material from positions some distance out from the center of the airplane. Provision has also been made for possible large ducts passing out through the wing in case it is found necessary to flow the dust out through manifolds, as in the case of spray, and disperse it from a number of large nozzles along the span of the wing. It it hoped, however, that satisfactory distribution can be obtained with simpler means.

Dust, some of which is highly inflammable, should be kept a safe distance from the power plant exhaust and as clear of the pilot as possible. The latter is facilitated by dispersing from under a low wing.

Loading must be easy and quick. The low-wing arrangement leaves the fuselage hopper opening entirely clear. The wing hoppers in a low-wing airplane should facilitate loading

A view of the Ag-1 airplane developed at the A. & M. College of Texas

by hand, which is the usual practice, but they might increase the time required if a mechanical loader is used.

Liquid Materials and Spray. Provision is made for a quick change from the use of dust to the use of spray, and vice versa. Two spray tanks are located in the center section of the wing and fitted with synthetic rubber liners. These liners will withstand the various chemicals used, and special liners can be used for special materials such as 2-4D which can not be cleaned out of a tank satisfactorily. A large oval door, 10 by 16 in, is provided in each tank for easy access and cleaning, and for easy filling when the liquid is poured in by hand. In the initial arrangement for spray distribution, which can later be changed as the development indicates, a positive-displacement, lobe-type pump is used. This pump will deliver up to 55 gpm at any pressure up to 100 psi.

The spray booms are located in the space between the wing proper and the flaps, which cover the entire span of the wing. In this position they are out in the open and accessible for maintenance purposes but do not add a significant amount to the drag and power requirement of the airplane. It is expected that a wide variety of nozzles will be experimented with, but the first work will probably involve the relatively large droplet sizes which appear to be desirable for herbicides and for some insecticides.

A mechanical drive from the engine was first installed to operate either the spray pump or an agitator for the dust hopper. This results in a substantial power saving over that required for a windmill drive.

A disk clutch was provided so that the pump and agitator could be operated only when needed. It does not wear or absorb power during take-off or cross-country flying. From the experience to date with the mechanical drive and disk clutch, it appears that it will be difficult to obtain reliable and extended operations from the type of drive used unless it is made more substantial and heavier. It is now planned therefore to change to a hydraulic drive.

A valve-and-pipe arrangement is to be included to enable the pump to be used also for filling the spray tanks from containers on the ground, or from an irrigation ditch.

THE PLANE

Performance. The airplane is to be capable of operating regularly from small, soft turf strips. Take-off from a soft field and climb to 50 ft within a distance of 1/4-mile has been set as the minimum designed requirement. To accomplish this most readily, the airplane is fitted with a fixed conventional landing gear having reasonably large wheels and tires. Some operators suggested a tricycle gear, and it is hoped that ultimately one can be tried with special provisions for take-off in soft terrain, i.e., a large nose wheel which can be held extended to give the wing a high-lift angle during the entire take-off run.

The desired operating speeds for dusting or spraying ranged from 60 to 90 mph with buoyancy available for zooming up over trees and wires at the end of the run.

For safe flight with acceptable bouyancy while dusting or spraying at 60 mph, it appears that the minimum flight speed should not be over 45 mph with full load. With the airplane light, the minimum flight speed will then be approximately 37 mph. These minimum speeds are being obtained with a large high-lift wing (7.5-ft chord and 39-ft span) and a full-span slotted flap.

A cruising speed of 90 to 100 mph for cross-country flight is satisfactory to most all operators, and has been obtained in our design.

Endurance at three-quarter power for two to three hours was satisfactory to most operators but four hours has been provided for convenience in ferrying and for operations at some distance from fuelling stations.

In order to meet these performance requirements the experimental airplane is provided with a 225-hp engine. Provisions are made also for possible use of engines of higher power which may be desirable under certain conditions such as high altitude.

Flying Qualities. Excellent maneuverability is required at low speeds. The airplane must be able to pull up sharply and make sharp turns at the end of a run without stalling or mushing or losing lateral control. The problem of attaining a responsive enough lateral control at low speeds and very high-lift coefficients is a difficult one and special means to aid in this matter have been provided, including the use of slot-lip ailerons or spoilers.

The operation of all controls and the reading of the instruments should be extremely simple, because the pilot must pay close attention to his flying while close to the ground. The controls are cut to the minimum possible and an attempt has been made to locate them so that they can be operated easily by feel alone. It is thought likely that a single-flap setting can ordinarily be maintained for the entire cycle of taking off, spraying or dusting, and landing.

Adjustable seat and rudder pedals are provided to cover the different conditions of operating and cruising, and for pilots of different size.

Provisions for flying before daylight and after dark are required by many operators. These include position lights and lighted basic blind-flying instruments (turn and bank, compass, and sensitive altimeter).

Field of View. An excellent view, forward and down, is very important for low-altitude dusting and spraying, and for clearance of fences, trees, wires, etc. Making turns at low altitude at the end of each swath requires a clear field of view in the direction of turning; a low-wing monoplane is the best configuration for this purpose. Some pilots desire a clear view to the rear in order to see the swath they have been laying. A good view ahead over the nose is desirable for taxiing in small unprepared fields.

LOW-WING MONOPLANE FULFILLS REQUIREMENTS

It appeared that the arrangement that best fulfills most of these requirements would be a low-wing monoplane with the pilot located high and in the front, and with a flat engine (as a tractor arrangement is used). Improved view over the nose can be obtained in flight by operating with the flap deflected to a suitable angle.

Protection of Pilot. Adequate protection for the pilot in a crash is extremely important because a certain number of crashes can be expected due to continued operation in close proximity to the ground. Full use has been made of information available from Cornell University's medical college crash injury research. From the standpoint of protection in a crash, it would be desirable to locate the pilot in the tail end of the airplane, with a large amount of structure ahead of him. Our design, which is a compromise, locates him in the center of the fuselage, above the rear portion of a large metal wing, and behind all loads. The field of view is favored by locating him high in the fuselage. A very strong seat, a seat belt, and a shoulder harness are provided, capable of taking a load of 40 g. The shoulder harness is fitted with an inertia reel giving freedom to the pilot under ordinary conditions but locking as soon as a crash and its resultant deceleration occurs. The pilot can lock the shoulder harness in advance if he desires.

In order to make the shoulder harness easy to use (and somewhat awkward not to use) the lower end of the left shoulder strap has been linked permanently to the left side of the belt and the lower end of the right shoulder strap to the right side of the belt. The pilot then has only one buckle attachment to handle, and it appears that the arrangement is being accepted by the pilots as a substantial improvement.

A pilot's headrest is provided strong enough for a turnover structure, and guards are provided from the front of the open cockpit to deflect wires and branches over the pilot's head. A cable is stretched from the headrest to the top of the vertical fin to deflect such wires over the tail or to cut them.

Maintenance and Repair. It is extremely important that the airplane be maintained easily and repaired quickly in order to keep it in operation without loss of time during the busy season. An attempt has been made to have all parts rugged, simple, and extremely reliable.

It was desired to use an engine that is in production now with parts and service easily available, and one that is also likely to be available and in general use several years from now.

Because the cost of a flat engine is approximately two-thirds that of a radial engine of the same power, it appears

that in the near future flat engines will be the only ones available in the sizes being considered here. The selection of a flat engine was strongly influenced by these reasons in addition to the main one of a better field of view for the pilot. The airplane design has been arranged, however, so that the entire power plant section ahead of the fire wall can be easily replaced by a radial installation if desired.

The operators are practically unanimous in desiring aluminum-alloy propeller blades because of their ease of repair. If satisfactory take-off performance can be obtained, it appears that a one-piece aluminum-alloy propeller would be simplest and would give the most reliable and trouble-free service. A number of operators, however, feel that a variable-pitch propeller is desirable because of the improved performance, and preferably one having aluminum-alloy blades. The airplane is now fitted with a one-piece aluminum-alloy propeller, but we hope to make comparative performance tests with both types.

There are different schools of thought regarding whether the structure should be of sheet metal, or whether fabric covering should be used over a steel-tube fuselage. Many small operators prefer the steel tube and fabric structure because they now have facilities and experience for repairing them. The larger operators, however, have facilities for repairing all-metal airplanes and feel that the work can be done at least as quickly and cheaply. Considering advantages of and the trend toward all-metal construction, our experimental airplane has been fabricated from metal. Simple sheets with single curvature have been used which can be repaired relatively easily in the field. The wing-hinge fittings and parts of the control linkage have been cut from flat plates of readily obtainable material, mainly unheat-treated chrome-molybdenum steel and 24ST aluminum alloy. No castings or forgings are used. On the basis that the airplane was constructed in this simple manner in a small shop with little equipment, it appears reasonable that repairs in the field would be relatively easy to make.

As many parts as possible have been made easily replaceable, including wing tips, stabilizer tips, landing gear, tail wheel, etc. Where possible, parts requiring maintenance have been placed in open so that they are easy to inspect and repair.

The landing gear is of the simple spring-steel type developed by Wittman and used by Cessna. This type has very few moving parts and requires practically no maintenance except for the wheels and brakes. The tail wheel is also supported by a single-leaf spring.

Weathering. A duster or sprayer airplane is likely to be kept out-of-doors a large part of the time, particularly throughout the busy season. In coastal areas the air may be both moist and salty. The airplane should, therefore, have a finish to withstand these conditions, as well as the ravages of direct sunlight. In this regard metal covering appears superior to fabric.

Corrosion from Chemicals. One of the major maintenance problems is that of corrosion caused by the agricultural chemicals, particularly the fertilizers. The following two provisions are being made to take care of this problem in our experimental airplane:

1 The main surfaces that come in contact with agricultural materials are protected by a vinyl base finish which has been recommended by Battelle Memorial Institute to resist all of the main corrosive chemicals involved, and which has been found effective against representative fertilizers in corrosion tests of our own.

2 An attempt has been made to construct the airplane simply and so that it is easy to clean thoroughly. This has been facilitated by the use of a simple open-metal structure, accessible from both sides, and suitable for flushing with a hose.

MEASUREMENT OF DISTRIBUTION

We are in the process of establishing a measuring station over which we hope all forms of aeronautical dispersing equipment for agricultural materials may be flown, and the distribution pattern measured. The initial plan is to obtain a cross section of the swath by obtaining samples located approximately 5 ft apart over a lateral distance of at least 100 ft. Among other things it appears desirable to evaluate the density of the material distributed in terms of the weight per unit area; for example, in pounds per acre. To obtain this value with as little laboratory labor as possible and as quickly as possible, we are collecting the dust or spray on the pans of balances and weighing it immediately after it falls, without disturbing it in any way.

Starting in this direction we have reworked 21 inexpensive chemical balances (pulp type). In place of one pan we have put a platform of thin aluminum sheeting, which extends over the entire balance and collects the dust or spray. This is supported directly on one knife-edge and is maintained in a substantially horizontal position by means of a weight supported on a post extending directly below it. The platform is made 16.625 in square, because an even weight of 20 mg on this area is equivalent of one pound per acre. The balance is sensitive to about 1 mg, which corresponds to 1 per cent at a spread of 5 lb per acre.

PENDULUM BALANCE ARRANGEMENT SAVES TIME

In order to obtain readings quickly without balancing each load individually in the usual time-consuming process, we have devised a pendulum balance arrangement which gives a direct reading on a scale for values up to 200 mg (or 10 lb per acre). This has been done by extending the usual pendulum arm, providing a new scale reading from 0 to 10 lb per acre, and adjusting the weight on the pendulum to correspond. For quantities greater than 10 lb per acre, coarse weights representing this amount are added, sufficient to make the pointer balance on the scale, and the intermediate quantities are read from the scale.

In order to cut the oscillation time down to a reasonable amount before a reading can be taken, air damping has been resorted to. The entire balance system is enclosed in a sealed box. During the dusting or spraying operation the platform forms the top of the box and is clamped into a position removed from the knife-edges of the balance. During the weighing operation a cover is put over the box, sealing it from outside air currents, and the platform is lowered onto the knife-edge of the balance by a control from the outside. As the pendulum swings, the platform moves up and down and the damping can be controlled to a fine point by adjusting the space between the platform and the sides of the box. At a clearance of 1/4 in the pointer comes to rest in approximately 30 sec, which appears optimum at this stage of our progress. A window is provided for reading the scale from the outside and a door is provided for changing the coarse weights.

As is usually the case in the development of a new technique, a number of difficulties have presented themselves. The greatest of these has been the condensation of moisture from the atmosphere on the weighing pans and other parts of the balances, and the evaporation of the condensed moisture while the pans are open for a test run. In order to obtain as still air conditions as possible we have found it advisable to run the tests in the early morning just after daybreak. Under the atmospheric conditions existing at that time of the day, immediately after the covers have been removed, dew has formed on the balance pans at rates as high as 10 or 12 lb per acre. Our experiments have shown that the dew formation can be minimized by keeping the air temperature inside the balance box a degree or two higher than that of the outside air. The most important single factor, however, has turned out to be extreme cleanliness of the pans, for the dew formation seems to be greatly encouraged by a slight film of foregn material, even one that is hardly noticeable.

When the distribution of spray is being measured, the evaporation of the spray itself after it has collected on the pan is also of course a source of error. The rate of evaporation has been found to be low enough, however, so that in the short time required to weigh the material after it has fallen, the error produced is not excessive, probably well under 10 per cent in most cases. After sufficient data have been attained to give a relationship between this evaporation and the temperature and humidity of the air, it should be possible to apply a correction that will substantially eliminate the evaporation error.

At the present time usable results are being obtained al-

though the experimental errors are still greater than desired and work will be continued to reduce them. After an acceptable test routine has been developed for weighing a cross section of the distribution, the measurements will be extended to include other items such as the variation of droplet size and dust-particle size within the distribution pattern.

With some initial results the measuring station is beginning to get under way. We plan to obtain a fund of information on all the more promising forms of equipment now in use by many different operators and also on forms of equipment that we ourselves develop for use on the Ag-1 airplane. We hope that this will furnish a needed aid to the operators in the near future, and that ultimately it will help toward more effective equipment and improved crop production for the farmer.

TABLE 1 PRELIMINARY SPECIFICATIONS FOR EXPERIMENTAL AGRICULTURAL AIRPLANE MODEL Ag-1
under development at Texas A. & M. Personal Aircraft Research Center

Type: Duster, sprayer, seeder, and fertilizer, single place.

Performance (estimated, full load): Maximum speed 115 mph; cruising 100 mph; operating speeds 60 to 90 mph; landing 45 mph (normal landing without pay load 37 mph); rate of climb 600 fpm; service ceiling 12,000 ft; cruising range 400 miles; take-off distance to a height of 50 ft, 1500 ft.

Specifications: Wing span 39 ft 10 in; length 29 ft 8 in; height 8 ft 7 in; empty weight 1900 lb; gross weight 3400 lb; fuel capacity 48 gal; low wing, all-metal construction, landing gear tail wheel type; Cessna type spring steel gear support as shock absorber for both main and tail units; tire size main gear 8.50 x 10, Goodyear tires, wheels, and hydraulic brakes; Scott 8-in tail wheel, steerable full swivel; Beech Bonanza rudder pedals; Continental E 225—104—14X engine, fuel consumption 12 gph; McCauley one piece aluminum alloy propeller.

NOTEWORTHY FEATURES

1 Performance and handling qualities are adapted to dusting and spraying work (flying with heavy loads from unprepared fields, flying low over crops at relatively low speed, and climbing over obstacles and turning back quickly for next pass), obtained with aid of fullspan slotted flaps and slot-lip ailerons.

2 The dust hopper is in the fuselage (27 cu ft) and spray fluid tanks (150 gal total) are in wing center panel, either available for use at any time.

3 Provisions were made for experimental installation of any promising equipment for dusting, spraying, seeding, or fertilizing.

4 Room has been provided in the outer wing panels for experimental dust hoppers to investigate possible improved distribution.

5 Simple construction has been used for ease of maintenance and repair.

6 An exceptional field of view has been provided for the pilot, particularly forward and downward while in flight.

7 Sharpened landing gear legs, guide tubes over cockpit, and a cable from the cockpit to the top of the fin, are all provided, for protection against electric wires contacted in flight.

8 Pilot protection in a crash is provided, including a 40g seat, belt, and shoulder harness, the latter supported by an inertia reel giving pilot freedom of action while protected; the pilot is located behind loads and all heavy masses, and protected by a long forward structure and the low wing.

British Consider Agricultural Aircraft

THE Journal of the Royal Aeronautical Society, in its January, 1952, issue, carried a paper on "Aircraft in Agriculture" by P. H. Southwell (Associate Member ASAE), assistant experimental officer, National Institute of Agricultural Engineering (Wrest Park, Silsoe, Bedfordshire, England). In his paper Mr. Southwell has reviewed briefly the history of agricultural use of aircraft in the United States and the British Commonwealth and discussed various aspects of the subject as follows.

Applications of aircraft in agriculture for transport, farm services, surveying, application of agricultural chemicals, and sowing of fertilizers and seeds; aircraft and performance requirements; deposition of materials from aircraft; considerations in the free emission of liquids from aircraft, especially as to large-scale spraying, small-scale application of liquids, application of smokes, and dusting; considerations in the free emission of solids from aircraft, as in sowing of seeds and fertilzers; considerations in flying; equipment for application of materials from aircraft; operation and maintenance of aircraft; costs; and the future of agricultural flying. He pictures opportunity for development as including the small, single-engined family farm plane, fleet operations of single-engined planes and helicopters by contractors and twin-engined craft with specialized equipment.

Fuels for Defense Production in Agriculture

By R. M. Sharp
Assoc. Member ASAE

IN THE last three decades tractors and trucks have replaced horses and mules as a major source of power in agriculture. There are less than 30 per cent as many horses and mules on farms as in the peak animal power year of 1918. The horse and mule population in the United States declined from an all-time high of 26,723,000 in 1918 to 7,463,000 in 1950 according to a USDA Bureau of Agricultural Economics report. To adequately replace this nation's 3,550,000 tractors on its farms in 1951 would require (allowing 15 hp per tractor and an output of 0.785 hp per horse) nearly 70,000,000 horses and mules. Assuming there are 2,500,000 female horses of breeding age in the United States, in 10 years we could only hope to bring the total number of work animals to possibly 13,000,000. This situation alone would spell certain disaster in *peace* or *war* in the event we became entirely dependent on animal power due to lack of motor fuel for agricultural use.

During the period 1918 to 1950, acreage of harvested crops used for producing feed for animal power in agriculture decreased from 90,000,000 to 25,000,000 acres. The U.S. total harvested crops in 1918 was 362,000,000 acres and 364,000,000 acres in 1950. The 65,000,000 acres of cropland released from the animal power feed area, or one-sixth of the total acreage of harvested crops, became available for production of food and fiber for human use.

To return to animal power on American farms would cut the productivity of the present-day farm worker in half, according to data from the *Economic Almanac* for 1950, which shows that employment in agriculture compared with total employment was 30.9 per cent in 1910 and decreased to 15.9 per cent in 1945. This means that more than 7,000,000 workers (to make up for the near 50 per cent reduction in output of the present day 7,300,000 workers on farms) would have to be pulled out of other industries and possibly the armed forces to maintain our present output of food and fiber with animal power. This would throw the nation's labor supply dangerously out of balance.

While it is true that some of the workers, in the population shift away from farms of the last 30 years, have entered the farm equipment manufacturing industry (about 4 per cent), by far the greatest proportion has been absorbed by other industries vital to national defense which contribute little to food production.

To further complicate converting back to animal power would be the problem of replacing nearly all present-day implements on the farm. Mounted cultivators, planters, mowers; power-driven combines and cornpickers; hydraulically controlled plows and disk harrows would all be rendered completely useless with a return to animal power. It is difficult to estimate the number of tons of steel, already in short supply, which would be required to revert back to horse-drawn implements.

All of these factors — the excessively high number of workers that would have to be commandeered from other vital industries, the drastic reduction of available food for human consumption after draft animals were fed, the scrapping of nearly all present-day implements and subsequent replacement by horse-drawn tools, and finally the indefinitely long time (twenty or more years) which would be required for an effective horse and mule population to be built up — show beyond a shadow of a doubt that any notion that our nation's agriculture could possibly return to animal power would be absurd and completely infeasible.

Abstract of a paper presented at a meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers at Peoria, Ill., October, 1951.

The author: R. M. SHARP, central sales division, general sales department, Caterpillar Tractor Co.

A Graduate Program in Agricultural Engineering

By A. W. Farrall
MEMBER ASAE

MANY schools now find that it is impossible to develop a fully trained agricultural engineer in four years, that is, a man who has the training which is needed for outstanding leadership in teaching, research, or industry. In an attempt to remedy this situation, some schools have gone to a five-year curriculum in engineering. However, it is believed that a relatively small percentage of the total number of engineers have the interest and qualifications which will make it worth their time to take a fifth year when they might be out getting experience in industry. For that small percentage of outstanding individuals, who wish to fit themselves for more specialized training and who have the capabilities for outstanding development in leadership, the graduate program has much to offer.

There are many opportunities for the man with the master's degree or the PhD degree. In leading institutions at the present time staff members find that an advanced degree such as an MS is almost a necessity. There is a demand for individuals with a PhD. Industry has hired our graduates with the advanced degrees at a premium.

It would appear that the future growth and welfare of the profession will depend to a great extent upon the leadership we are able to develop within our profession. Here is an opportunity for the colleges to select outstanding young men for further training and indoctrination which will fit them to be leaders in college and industry. We must have men of the same high training and caliber in agricultural engineering as in other professions.

Requirements for a Graduate Program. The success of a graduate program depends on a good many things. (1) A capable and well-trained staff that can give the proper guidance to the resident student is a necessity. (2) Facilities should be available which will enable the student to accomplish something worth while. (3) A system for proper selection and evaluation for students is essential. It is inefficient and a waste of time to accept graduate students who do not have the intellectual, moral and character requirements for leadership and development. (4) It is important that there be available sufficient operating funds so that the graduate student may accomplish something worthwhile. (5) There should be a proper atmosphere or spirit around the institution. It should encourage individual thinking and the broadening and development of the student, not only along the technical lines, but in the broad aspects of education. (6) The program should be well organized so that students are properly orientated and a certain amount of guidance provided. Some people in the past have thought that the method of throwing a man in and letting him sink or swim, so to speak, was a good way to develop a graduate student. We believe that a certain amount of guidance is necessary in the interest of efficiency and in the proper development of the student. At Michigan State College all of our graduate work in the agricultural engineering department is under a supervisor of graduate students who assists the students in every way possible. Students are, however, assigned to individual instructors since there are more students than one man can handle efficiently. We find this system works very well. (7) It is necessary to have certain minimum requirements for maintaining the graduate status.

Each of our graduate students is required to follow a course of study which is tailor made to suit his requirements. It is based, however, upon considerable emphasis on mathematics and physics as basic sciences. Supporting courses are taken from other departments, including chemistry, electrical engineering, or whatever is needed to make a satisfactory program.

An address at a joint dinner meeting of the Research Committee of the Farm Equipment Institute and representatives of agricultural engineering research in public service agencies, at Chicago, Ill., December, 1951.

The author: A. W. FARRALL, head, agricultural engineering department, Michigan State College, East Lansing.

A grade of B or higher is required in each course for which credit can be given.

An important part of the graduate student's program is the research problem and the writing of a thesis. In connection with the master's degree approximately one-third of his total credits are given for research and in the PhD degree program approximately one-half of the credits are for research. This emphasis on research serves to give the student an opportunity to do some original thinking and to plan and execute a systematic research program. It also gives him experience in the preparation of reports. There is ample opportunity for the student to express his originality and to develop good work habits and research techniques in connection with this program. We also try to broaden the student's general training and develop his personality.

Types of Graduate Students. There are several principal types of graduate students, including graduate assistants, graduate research assistants, and graduate fellows. In general, the program of the one-half time graduate teaching assistant is made up so that he will spend approximately 20 hours per week assisting in some teaching activity. The remainder of his time is given to taking regular college courses and working on a research problem for which he will write a thesis. Most of the graduate teaching assistants are financed directly by the college.

A one-half time graduate research assistant is expected to spend about 20 hours per week on some research problem and the remainder of his time going to school. His research problem may be an experiment station project or some problem in which the department is interested. It is usually arranged so that the student may use the research problem for his thesis, although this is not essential. The graduate research assistant is usually financed by the college directly or from a grant-in-aid from a foundation or some commercial concern.

The graduate fellow is usually an individual who also spends about 20 hours per week on a research problem and the remainder of his time going to school; however, a graduate fellow is usually supported financially by an industrial concern, and it is stipulated that he must work on a specific problem which is outlined by the sponsoring organization.

Graduate Assistantship and Fellowship Program. This is one means of providing financial assistance to the graduate, both in the way of helping him to defray his operating and living expenses and also providing a certain amount of operating expenses in many cases.

We look upon the graduate assistantship as an incentive for capable students to take advanced work. In most instances the actual pay which the assistant receives is only a small fraction of what he really deserves. However, it does serve to help him along with his graduate training program and for that reason is of great value. It enables many capable young men to take graduate work who could not otherwise do so.

I believe that the industrial research program is of particular interest. Under this program an industrial concern may make a grant-in-aid to an institution. The grant is used for paying an assistantship of, say \$100 to \$150 per month to the student. Usually some operating funds are also provided. Such a program, of course, is of interest to students who may wish to take advanced work. However, I believe it is of even greater value to the sponsoring concern. In our own experience we have been very well satisfied, and I believe the industrial concerns have been satisfied with the results of the program, since the money so contributed not only helps to develop a young man, but in most instances it also accomplishes some research program of value to the company or to the profession. In some instances the problem studied is of particular interest mainly to the sponsoring company. However, in many instances the work is of general nature which is of use to the industry. *(Continued on page 368)*

Instrumentation in Agricultural Engineering Research

By Waldo H. Kliever
MEMBER ASAE

THE Committee on Instrumentation and Controls was set up by the ASAE for the purpose of studying means for the improvement of research, production, and processing in agriculture through efficient use of instruments and controls. It was felt that one means of contributing to this objective would be to accumulate certain experience data so that research workers might refer to various individuals for information on instrumentation problems. This data was contributed by a total of 72 institutions, companies, and individuals and relates 150 people with certain instrumentation experience. The Committee appreciates the interest shown by these people in supplying the data included in the report and hopes that further exchange of instrumentation experience will follow. Such information should be directed to Karl H. Norris, Agricultural Research Center, USDA, Beltsville, Md.

Since the complete instrumentation experience report is too lengthy for publication, it will be made available to anyone wishing a copy on request to the Society headquarters office. The report includes measurements of temperature, humidity, moisture in materials, position, pressure, fluid flow, liquid level, gas, power (transducers), radiation, color, and other. In most cases these classifications are divided into various subheads according to the basic principles employed. The following tabulation lists the various measurements reported and the number of individuals reporting experience in each general classification. The complete report referred to above includes the names and addresses of individuals reported as having experience with each of the measurements.

TEMPERATURE MEASUREMENTS

Animals, Fowl, etc. Shelters 2, cattle stalls 2, animal surface 1, skin temperature 1, psychroenergetic laboratory 1, incubation 1, brooding 3, poultry house 2, broiler house 1, poultry calorimeter 1, bees 1.

Food. Fruit refrigeration 1, food processing 2, food freezing rate 2, heat transfer in food 1, frozen food studies 4, fruit and vegetable transportation 2, storage and handling frozen fruits and vegetables 2, milk 4, eggs 1, water 12, convection currents fruit sulphuring 1.

Crops. Storage temperature 1, grain storage 7, hay storage 7, potato storage 8, sugar beet storage 1, silage 4, drying 2, drying chamber 1, forage drying 4, cotton drier 1, hay drying and curing 10, grain drying 3, flax drying 1, flax retting 1, sugar beet cooling 1, tobacco barn temperature 2, tobacco curing 4, tobacco oven control 1, tobacco leaf temperature 1, tobacco temperature rail shipment 1, seed sterilizer 2, processing long vegetable fibers 1.

Equipment. Heat-exchanger tests 1, heat pump studies 5, refrigeration 12, heat treating 1, engine testing 1, electric oven 1, flame cutoff 1, gas burner control 2, LP gas control 2, motor winding temperature 1, ammonia tank temperature 1.

Materials. Heat-transfer studies 6, structure studies 2, fire resistance studies 1.

Weather and Environment. Air 22, air conditioning 4, weather 3, frost control 1, ventilation 3, farm buildings 3, housing research 2.

Other. Wet and dry bulb 7, calorimetry 2, dew point sensing 1, thermoelectric cold junction 2, liquid 1, sample temperature 1, soil 10, storage cold box 1, manure pack temperature 5, process material 1, process control 3, purpose not specified 20.

HUMIDITY MEASUREMENTS

Animals, Fowl, etc. Farm building environmental studies 3, barn ventilation studies 11, brooding 6, broiler house studies 2, poultry house condition 2, poultry calorimeter 1.

Food. Food storage 3, fruit storage 1, transpiration studies fresh and frozen fruits and vegetables 1, storage and handling fresh and frozen fruits and vegetables 1, storage and handling fresh and frozen fruits and vegetables 1, freezer storage humidity 2, freezer storage humidity control 1.

Crops. Grain storage 10, seed storage 2, corn storage 4, potato storage 6, potato storage (sweet) 1, forage storage 2, crop conditioning 1, drying studies 2, dehydration studies 5, grain drying 3, forage drying 9, hay curing 2, tobacco curing 4, sugar beet cooling 1, equilibrium vapor pressure tobacco 1, seed processing 1, grain moisture content 1, seed moisture measurement with salts 1, cotton ginning 1, equilibrium moisture tests 1, equilibrium moisture content wood 1, processing long vegetable fibres 1, hydrological studies 1.

Equipment. Refrigeration 5, heat-exchanger tests 1, heat pump studies 1, engine testing 1, fan testing 1, condensation tests on freezer cabinets 1.

Materials. Plywood fire-resistance studies 1, lumber 4.

Weather and Environment. Air conditions 21, air conditioning 1, weather 5, farm home studies 6, room humidity reading 2.

Other. Drying chamber studies 1, measure absolute humidity 1, measure moisture $CaCl_2$ absorption 1, moisture control 2, air handling 1, condensation control 2, check hygrothermograph 4, purpose not specified 12.

MEASUREMENT OF MISCELLANEOUS VALUES

Moisture in Materials. Grain 23, corn 7, seeds 8, seed products 4, seed storage 2, seed processing 2, cotton 1, silage 3, forage 5, forage-thermal conductivity 1, hay 21, hay-hot oil submersion 1, bedding 1, straw 1, litter 3, flax straw 1, flax fiber 1, linen 1, processing long vegetable fibers 1, dried fruit environmental studies 1, storage and handling fresh and frozen fruits and vegetables 1, dairy products 1, soil (nylon blocks) 2, soil (Bouyoucos blocks) 4, soil 19, clay samples 1, concrete 1, refrigeration 1, insulation 1, wood and wood products 9, lumber 1, glue studies 1, drying experiments 2, purpose not specified 13.

Position Measurement. Drawbar dynamometer 2, drawbar pull 1, torque dynamometer 1, draft studies 2, weight loss (insensible) 1, barn design 1, prefabricated wall panel tests 1, prefabricated truss beam tests 1, grain pressure bin walls 3, laboratory tests 3, machine member stresses 2, refrigeration 1, wind direction 1.

Pressure Measurement. Air 9, gas pressure human energy studies 1, barometric pressure 2, static pressure 1, vacuum system studies 1, hydraulic pressure 1, drying experiments 2, forced air drier studies 2, ventilation studies 1, air conditioning 1, storage and handling fresh and frozen fruits and vegetables 1, fruit sulphuring 1, crop conditioning 1, grain drying 6, grain storage 1, corn drying 2, sugar beet cooling 1, flax drying 1, hay drying 4, silage studies 2, irrigation studies 5, soil water holding studies 1, water flow studies 1, process conditions 3, wood impregnation studies 1, plastic surface and adhesive studies 1, wind tunnel hay blowers 1, heat pump studies 1, refrigeration 8, ammonia tank pressure 1, pressure artesian wells 1, drawbar dynamometer 11, engine dynamometer 5, engine testing 3, engine detonation 1, fan testing 1, boiler draft control 1, purpose not specified 7.

Fluid Flow. Air 29, air velocity through grain 1, air velocity through hay 1, water 12, water (weir) 2, liquid flow 2, air conditioning 1, ventilation studies 8, structure infiltration 1, determine duct center factors 1, process conditions 1, food processing studies 1, transportation studies fresh and frozen fruits and vegetables 1, storage and handling fresh and frozen fruits and vegetables 1, crop drying equipment tests 7, drying 6, grain drying 1, hay (Continued on page 368)

Report of the Committee on Instrumentation and Controls, ASAE.

The author: WALDO H. KLIEVER, director of research, Minneapolis-Honeywell Regulator Co. (Minneapolis, Minn.) (Chairman, Committee on Instrumentation and Controls, ASAE.)

Instrumentation in Agricultural Engineering Research

(Continued from page 366)

drying 5, flax drying 1, tobacco curing 1, tobacco curing-duct flow 1, potato storage 4, processing long vegetable fibers 1, weather 7, irrigation studies 13, drainage studies 1, soil erosion studies 2, refrigeration 2, refrigerant flow 3, engine testing 2, tractor laboratory tests 2, fan testing 8, pump testing 1, anhydrous ammonia flow 1, anhydrous ammonia metering 1, grain fluidizer 1, grain conveyor tests 1, hay blower tests 1, wind tunnel tests 1, vacuum pump tests 1, calibration vane anemometer 2, spray pump discharge 2, crop spraying equipment tests 1, purpose not specified 9.

Liquid Level or Quantity Measurement. Animal water consumption 1, water stage recorders 3, silage juice measurement 2, water meters 3, rain intensity gage 1.

Flue or Gas Measurement. Orsat type 6, human energy studies-measure exhaled air 1, furnace work 1, drying experiments 1, transportation studies fresh and frozen fruits and vegetables 1, storage and handling fresh and frozen fruits and vegetables 1, air fuel ratio meter 1, exhaust analysis 1.

Transducers — Power (Dynamometers). Belt and drawbar dynamometer 11, fan testing 3, grinding tests 1, power consumption and output 4, eddy-current dynamometer 1, air conditioning 1, purpose not specified 4.

Radiation Measurement. Cotton fiber investigations 1, test eggs — radio frequency, infrared, visible, ultraviolet 1, ultrasonic effects 1, effects on poultry — visible and ultraviolet 1, insect attraction — ultraviolet 1, frost control 1, fighting studies 1, chick brooder studies — infrared 2, radiant heat from tobacco curing stoves 1, wall surface heat losses 2, radiation from structural walls 1, crop storage and housing pyrheliometer solar radiation 1.

Heat Transfer. Heat flow storage and refrigeration walls 3, heat flow from animal skin 2, heat flow cow to floor 1, thermal warp properties of fabrics 1, wall conduction, thermopile calibrated blocks 1, concrete walls, corn cob filler 1, heat floor general 3, storage studies fresh and frozen fruits and vegetables 1.

Color Measurement. Spectrophotometer 3, dairy cattle hair characteristics 1, vegetable oil studies 1, egg yolk and shell studies 1, dusting and spraying studies with tracers 1, soil acidity 1, tobacco curing research 1.

Other Measurements. Process material — ph measurements 1, structural analysis of fibers by light emission 1, high-speed photography — strobotack and strobotlash 4, electric fence research 4, operation timing 1, compressor and condenser rating — refrigeration calorimeter 1, light meter 1, tobacco leaf reflectance and transmittance 1, photographic analysis wheel bounce 1, sound — electroacoustic-refrigeration 1, soil moisture — tensiometer 1, animal counting 1, viscosity 1, loads, stresses and strains 1.

A Graduate Program in Agricultural Engineering

(Continued from page 365)

The School's Contribution. The question is often raised by concerns who support graduate fellowships as to what the college contributes to the program; following are a few of the more important contributions:

1 Space and operating facilities

2 Guidance and supervision of the student and his program

3 Maintaining an atmosphere of inquiry and research which is necessary in order to stimulate the young investigator

4 Consulting service. It might be said that the entire facilities of a great university are available to a graduate student. He is able to request and usually obtain consulting service free of charge from any department on campus if, in his opinion, they can be of assistance in the solution of his problem.

Ordinarily the sponsor of assistantships contributes financial support, ideas, and encouragement to the graduate assistant.

When the contributions of the sponsor and the educational institution are added up, it will be seen that the graduate research assistant has a tremendous amount of help available to him. In a properly coordinated and organized program with a capable graduate student available, there is every ingredient present which is necessary to accomplish research work. It should be of great value to all three parties, namely, the student, the sponsoring company, and the educational institution.

Increase in Graduate Students. The importance of the graduate program is indicated by the increasing number of graduate students taking agricultural engineering, even in times when jobs are quite plentiful. At Michigan State College five years ago we had three graduate students. During the five years, the number has increased greatly and has averaged from 25 to 34 students per quarter year, and even at the present time with the tremendous demand for men, the enrollment in our graduate program is holding up well. Our graduate students are in general high caliber young men who could go out and get a good job any time they desired, but they have decided to prepare themselves in a more thorough manner for their life's work. The fact that many of them have been able to obtain an assistantship or fellowship has made it possible for them to obtain this extra training.

A graduate program for training specialists and leaders in the field of agricultural engineering offers one of the best means of obtaining outstanding men who can help to solve the problems of today and tomorrow.

RURAL ELECTRIFICATION SHORT COURSES

Representatives of rural electric power suppliers are shown here examining equipment for testing fans, in the agricultural engineering laboratory at The Pennsylvania State College. The course held November 12-16, 1951, featured crop drying and dairy-stable ventilation. In holding these courses annually over the past 20 years, the agricultural engineering department has emphasized teaching the fundamentals behind the applications. This helps the graduates to apply the principles under a variety of conditions.

NEWS SECTION

Centennial of Engineering

THE year 1952 marks the centennial of the first association of engineers (American Society of Civil Engineers) in the United States and therefore merits a nationwide celebration. Major Lenox R. Lohr, president of the Centennial of Engineering organization, writing in *Midwest Engineer* for November, 1951, stated that the Centennial plans envisage three major parts as follows:

1. The greatest convocation of engineers ever assembled, with over 40 technical societies with a combined membership of over 500,000, will meet jointly in Chicago between September 3 to 13, 1952. Foreign societies and prominent foreign engineers will participate, and the U.S. State Department is arranging for their entrance to this country. The many hundreds of papers delivered will cover almost every phase of engineering. Instead of being highly technical and directed to specialized groups, the discussions will be broader in scope so that members of other societies interested in activities collateral to or outside their usual sphere may fully understand them. It will present an unusual opportunity to receive highly accurate information and direction in fields not usually accessible. Each subject will be developed with appreciation of its social and economic implications, appropriate emphasis being laid on the unique opportunity that has been open to individual initiatve. They will close with a look into the future.

A volume will be printed listing all papers to be presented, and visitors may select and attend those meetings in any field in which they are interested. It will be a cafeteria of learning where the visitor may look over the array and select those which most intrigue him. There will also be a series of popular talks, frequently accompanied by demonstrations presented to the general public in non-technical language during the summer months.

2. There will be a dynamic exhibit at the Museum of Science and Industry epitomizing all engineering progress and its effects on our way of life. It will remain for five years and over eight million people will see it.

3. There will be a dramatic presentation, using all the arts of the stage, to tell the story to the general public. It will run through the summer months of 1952. It will be the story of civilization's march forward and particularly of a Century of Engineered Progress, it will be told factually and with real equipment. It will base its appeal on entertainment, and stimulating the emotions, but the story will be there so clearly depicted that the audience will deduce for itself why America is great and what we must do to preserve it and how easily it might be lost. Without propaganda, controversial or political issues, it will present the facts of our industrial growth. It will have high educational value and leave the visitor with a lasting message, vital to the future welfare of our country. Our system of free enterprise has given us what we have, and it must not be changed for a pot of gold at the end of a politician's rainbow.

These major activities will be centered in Chicago, but the celebration will be nation-wide, reaching the local sections of all participating societies, and the general public not able to attend personally. There will be motion picture films, a book for children and one for adults, a U.S. postage stamp, a commemorative medallion, radio and television programs, news stories, and a Hall of Fame for engineers.

Following is a summary of the main purposes of the Centennial.

1. Make known the contributions of the engineer in peace and war to our national progress.

2. Personalize the engineer in his true role.

3. Stimulate young men to study engineering to fill the future's great need of technically trained men in research and industry. In 1954 there will be only 17,000 technical graduates, while 30,000 will be critically needed in industry. As the peacetime use of atomic energy develops, the need may be still greater.

4. Depict the role of industry with its mass production as essential to our high standard of living, and its dependence on the engineer and management to maintain and increase our prosperity.

American industry, functioning under the aegis of a constitution which guarantees liberty, is the bulwark of world stability. Our munitions, machines, and food are keeping tottering nations free. To do so may be stretching our economy to the breaking point, but we still have enough to supply our own people abundantly. We are carrying both loads, because we have had a high degree of professional education, a patent system which protected ideas, sufficient risk capital, effective research laboratories, progressive management, competition to produce the best for the least, mass production to make enough goods to go around, and a high rate of employment, with large salaries, so enough people had the means to purchase them. We have the media of mass communication so all people are aware of what is available, mass transportation to ship the goods to the remotest corner of the country, and a sharing of the profits to all who would invest. This is the story the Centennial must tell.

ASAE Meetings Calendar

June 16-18—45TH ANNUAL MEETING, Hotel Muehlebach, Kansas City, Mo.

August 25-27 — NORTH ATLANTIC SECTION, University of Maine campus, Orono

September 8 and 9—ASAE PROGRAM, Centennial of Engineering Convocation, LaSalle Hotel, Chicago, Ill.

October 30 - November 1 — PACIFIC NORTHWEST SECTION, Oregon State College, Corvallis

December 15-17—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

Michigan, Ohio Sections in Joint Meeting

SUCCESS marked a joint meeting of the Michigan and Ohio Sections, at Maumee, near Toledo, May 3. Approximately 150 members and guests from membership centers in Columbus, Detroit and Lansing met each other half way Saturday, May 3, for their own Derby Day program. The meeting was held at the Toledo Edison Clubhouse on the Maumee River.

Stanley Madill, president, American Society of Agricultural Engineers, was the featured guest speaker at the noon luncheon of the combined sections. He was introduced by Chris Nyberg, chairman of the Michigan Section, doubling as toastmaster.

Reporting on his observations during the past year in attendance at ASAE Section meetings and other contacts, Mr. Madill noted strong interest in the field of agricultural engineering and the activities of the Society, both in this country and internationally. He presented a striking correlation between growth of ASAE membership as an index of progress in its professional and technical field, and the increasing numbers of tractors on farms as an index of progress in modernization and increasing production efficiency in agriculture. In concluding he said that we are in the midst of one of the greatest revolutions in agriculture that the world has ever seen, a revolution in which a limiting factor is trained manpower, and one in which agricultural engineers can make a major contribution to world peace.

Following registration at 9:30, E. H. Kidder, program chairman for the Michigan Section, called the meeting to order for the opening paper, "Tractor Stability in Pulling Contests," by D. M. Kinch, graduate research assistant, Michigan State College. "Propane as a Tractor Fuel," by B. J. Lamp, instructor in agricultural engineering, Ohio State University, was the second subject on the morning program.

G. W. McCuen substituted for W. H. Johnson, program chairman for the Ohio Section, as presiding officer for the afternoon session.

"Krilium as an Aid to Agriculture" was presented as an agronomic subject of significance to agricultural engineers, by Dr. G. S. Taylor, professor of agronomy, Ohio State University. Strong interest was shown in its potential influence on engineering factors in tillage, drainage, irrigation, and runoff control.

C. F. Culp, chief engineer, Aerovent Fan Co., reported on "Fan Characteristics and Design for Crop Drying Application," in the closing feature. His treatment dealt with aerodynamic principles and related design for efficient circulation of required air volumes against pressure heads commonly encountered in crop drying work.

In an announcement period closing the session, Chris Nyberg, chairman of the Michigan Section, reported that new Section officers elected in the recent mail ballot were J. R. Schram, chairman; E. L. Barger, Wm. G. Buchinger, and R. L. Maddex, vice-chairmen; R. G. White (re-elected) secretary. The newly elected nominating committee are K. L. Pfundstein, J. W. Shields, and D. E. Wiant.

Mr. Lamp, Ohio Section chairman, announcing the results of a similar Section ballot, reported its newly elected officers to be T. P. Christen, Jr., chairman; H. N. Luebcke, vice-chairman; and D. M. Byg, secretary-treasurer. The nominating committee are R. M. Gilbert, L. L. Harrold and B. J. Lamp, Jr.

The new chairmen both responded briefly with indications that they would do their best for their respective Sections, and invited the cooperation of Section members. (News continued on page 372)

NEWS SECTION *(Continued from page 370)*

Minnesota Section Elects Schober

WAYNE E. SCHOBER, chief engineer, Viking Tool and Die Co., is the new chairman of the Minnesota Section of the American Society of Agricultural Engineers for 1952-53. His election was announced at the annual Section dinner at the Curtis Hotel in Minneapolis on May 9. He succeeds Marvin J. Samuelson, research and design engineer, Minneapolis-Moline Co.

Other officers announced at this meeting are vice-chairman, Darrell W. Walker, parts and service merchandise manager, Northwest Tractor and Equipment Co., and secretary-treasurer, William F. Millier, instructor in agricultural engineering, University of Minnesota.

Directors to the Minnesota Federation of Engineering Societies elected by the Section, are Curtis L. Larson, instructor in agricultural engineering, and Andrew Hustrulid, professor of agricultural engineering, University of Minnesota. O. W. Kromer, owner and engineer, O. W. Kromer Co., is alternate director.

Arnold M. Flikke, assistant professor of agricultural engineering, University of Minnesota, was named contributing editor to the Minnesota Federation of Engineering Societies.

Named to the Section nominating committee were Basil B. Howell (chairman), sales manager, Rilco Laminated Products Co.; Leonard E. Nelson, engineer, Hitchcock and Estabrook Inc., and Virgil H. Johnson, assistant professor of agricultural engineering, University of Minnesota.

The annual meeting of the Section opened at 9:30 a.m. in the Agricultural Engineering Building at University Farm with Philip W. Manson, professor of agricultural engineering, presiding. Following opening remarks by Marvin Samuelson, Section chairman, Martin Ronning, chief engineer, power machinery division, Minneapolis-Moline Co., gave an illustrated talk on the development of the Company's Uni-Harvestor. A. C. Heine, superintendent of the Minnesota Agricultural Experiment Station farms at Rosemount, presented a preview of the experimental projects to be visited on the afternoon bus trip. Robert Calton of the U.S. Army Corps of Engineers discussed the recent floods and flood-control measures.

The afternoon session consisted of the chartered bus trip to the experiment station at Rosemount where University of Minnesota staff members explained and demonstrated some of the agricultural experimental work in progress there.

Marvin Samuelson, Section chairman, presided at the evening dinner meeting at the Curtis Hotel. The Minneapolis-Moline Gaucho quartet entertained with some very fine barber-shop harmony. Raymond Olney, ASAE Secretary, reported on some of the high lights and coming events of the Society. C. H. Christopherson, secretary-treasurer of the Minnesota Section, presented the annual report. A. J. Schwantes, chief, division of agricultural engineering, University of Minnesota, presented a report on the progress of his committee in their investigation of the facilities available for holding an annual meeting of ASAE in Minnesota. An invitation will be extended to the Society to hold the June, 1954, meeting on the Minneapolis Campus of the University of Minnesota.

Stanley Madill, president of ASAE, and executive engineer, John Deere Waterloo Tractor Works, addressed the Section. His subject was "Agricultural Engineering Today and Tomorrow."

The attendance for the dinner meeting was 64, and included 14 agricultural engineering students from the North Dakota Agricultural College. Visiting agricultural engineers included George L. Pratt and R. L. Witz of NDAC and F. W. Duffee and O. I. Berge of the University of Wisconsin.

FEI Industry-Research Conference in Michigan

ACTIVE interest in a wide range of agricultural and engineering research in progress at Michigan State College was shown by approximately 100 registrants at the Farm Equipment Institute Industry-Research Conference at Michigan State College, May 12 to 14. Those who attended represented a cross section of engineering and other executives of the farm equipment industry, supplemented by representatives of several other centers of agricultural-engineering research.

Featured addresses by John A. Hannah, president, Michigan State College, George D. Scarseth, director of research, American Farm Research Association, and W. J. Fisher, chairman of the executive committee of Farm Equipment Institute, and the address of welcome by E. L. Anthony, dean of agriculture, Michigan State College, were particularly challenging and well received.

Some surprise was evidenced in the amount of interest shown in reports by representatives of the various agricultural sciences on research in their respective fields, and in their interpretations of its significance to the farm equipment industry.

The Michigan hosts showed well-merited pride in the College, in the facilities provided by its agricultural engineering department and by Kellogg Center in particular, and in the performance of its football team.

Panel discussions on grassland farming, pest control, the animal industries, and soils and tillage problems covered major areas of interest. The program in detail developed substantially as scheduled and previously reported. *(News continued on page 374)*

NEWS SECTION *(Continued from page 372)*

Georgia Section Meets

THE largest group ever to attend a spring meeting of the Georgia Section, ASAE, gathered at St. Marks, Florida, on May 2 and 3. A general lack of fish was more than compensated for by story telling and fine fellowship.

Chairman W. D. Kenney, manager, design and development department, Southern Plow Company Division, Columbus Iron Works, Columbus, presided at the technical meeting on the afternoon of May 2. Program chairman, W. M. Bruce, associate agricultural engineer, BPISAE, Athens, presented R. H. Driftmier, head, division of agricultural engineering, University of Georgia, who spoke on "What Agricultural Engineers Are Doing." Charles E. Rice, assistant professor in the division of agricultural engineering, University of Georgia, gave an illustrated talk on the work of agricultural engineers at the three new branch agricultural experiment stations located at Plains, Midville, and Calhoun. The final paper was given by J. Irwin Davis, Sr., agricultural engineer, Caterpillar Tractor Company, Albany, on "New Machines and Techniques for Land Clearing and Pasture Renovation."

New section officers were named as follows: John T. Phillips, Jr. (chairman), executive vice-president, Lilliston Implement Company, Albany; James W. Harwell (vice-chairman), soil conservationist, SCS, Tifton; and Warren E. Garner (secretary), assistant agricultural engineer, College Experiment Station, University of Georgia, Athens.

Advisory Committee Preliminary Meeting

THE ASAE Advisory Committee to the Division of Farm Machinery, U.S. Department of Agriculture, held a preliminary meeting at Michigan State College, May 14 and 15, following the FEI Industry-Research Conference.

A review of current organization in the USDA and work in progress in the division was presented by E. G. McKibben, director of agricultural engineering research, R. B. Gray, chief of the division of farm machinery, and Frank Irons and Geo. W. French, agricultural engineers in the division.

This information, together with the functions and procedure of the Committee, were discussed during the remaining time available.

Members of the Advisory Committee present, in addition to E. P. Hanson (chairman), were C. E. Ball, E. L. Barger, D. H. Daubert, O. E. Eggen, L. W. Garver, G. W. Giles, F. H. Hamlin, L. W. Hurlbut, H. G. Ingerson, R. M. Merrill, R. R. Poynor, and C. J. Steinbrunner.

1953 International Meeting on Hydraulics

A JOINT meeting of the International Association for Hydraulic Research and the Hydraulics Division of the American Society of Civil Engineers has been scheduled to be held at the University of Minnesota the week beginning August 30, 1953.

The program is to concentrate attention on four specific technical phases of hydraulics, namely, (1) density currents, (2) air entrainment by flowing water, (3) waves, beach erosion, and by hydromechanics of shore structures, and (4) basic relationships of sediment transportation by flowing water.

Lorenz G. Straub, director of the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota, is president of the International Association for Hydraulic Research. His office has invited preliminary indications of interest in attendance, and contributions for consideration for the meeting program.

Horatio Alger Award to W. A. Roberts

W. A. ROBERTS, president, Allis-Chalmers Manufacturing Company, who was born on a small farm in the Missouri Ozarks near Salisbury, was among seven men who recently received the Horatio Alger Award in recognition of their rise from humble beginnings, through their own ability and industry, to their present positions.

Other recipients of the award included Charles F. Kettering of General Motors and Ralph Bunche, 1950 Noble Peace Prize winner.

PERSONALS OF ASAE MEMBERS

Richard K. Frevert, professor of agricultural engineering, Iowa State College, was recently appointed assistant director of the Iowa Agricultural Experiment Station.

George McConeghy, Jr., recently started work as junior project engineer in the product engineering department of the New Idea Division, Avco Manufacturing Corp., at Coldwater, Ohio. He was formerly in the mechanical products engineering department, Niagara Chemical Division, Food Machinery and Chemical Corp.

Edward L. Rietz, for three years chief development engineer of Lilliston Implement Co. of Albany, Ga., recently joined the Wigle Hoeing Attachment Division of the Auto Specialties Mfg. Co. at St. Joseph, Michigan, as development engineer. He will be in charge of the development of the Wigle hoeing attachment and other farm implements.

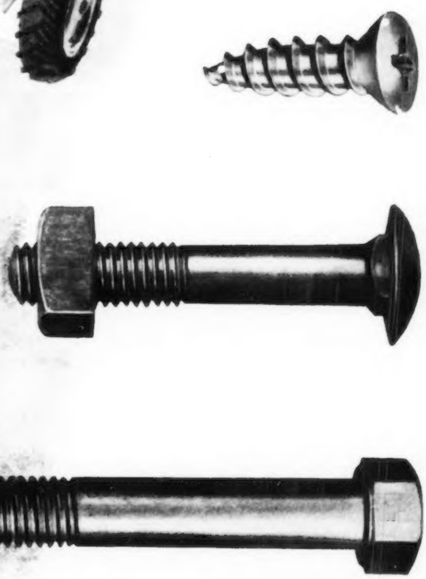
How did this work horse get so strong?

There's no mystery why the farm tractor can take it . . . can do almost any job, from cultivating to lifting loads, at the mere attachment of a different implement.

It's *built* to take it. Each part is strongly made . . . strongly *assembled*. Farm equipment makers, famed for their high standards of quality, realize that no product can be stronger than its fasteners, insist on such rugged RB&W products as . . .

- Slotted or recessed head Tapping Screws threaded close to the head to hold in thin gauges of sheet metal.
- The new short square Carriage Bolts . . . designed for farm equipment. Can be used in thin metal sections with the square hole punched in only one section.
- Bolts and Cap Screws of all varieties . . . heat-treated to obtain the best combination of tensile strength, toughness and ductility for heavy load conditions.

RB&W is proud that the strength of its products is helping to make strong the superior farm equipment of America.



RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

RB&W
THE COMPLETE QUALITY LINE

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Dallas, Oakland. Sales agents at: Portland, Seattle.

106 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

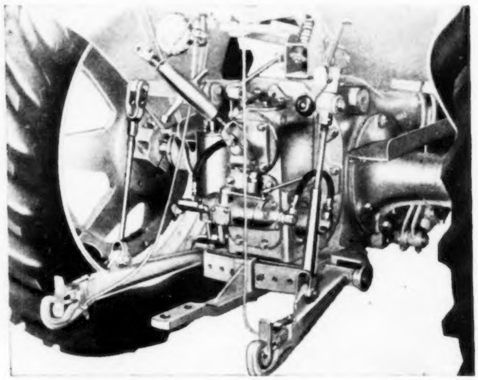
NEWS FROM ADVERTISERS

New Products and Literature Announced by
AGRICULTURAL ENGINEERING Advertisers

New Case Eagle Hitch and Other Features The J. I. Case Co., Racine, Wis., has announced introduction of SC and DC Eagle Hitch tractors, Eagle Hitch implements, live or continuous-running power take-off, live hydraulics, and double-disk self-energizing brakes.

A Case VAC Eagle Hitch tractor and implements were introduced in 1950. Case now offers the Eagle Hitch on their larger two-plow tractor, equipped either with the single or dual front wheel. The Eagle Hitch will also be available on the still larger DC-3 all-purpose tractor; also on the DC-4, a 4-wheel tractor which can be changed from a four-wheel to a row crop all-purpose unit, or vice versa, by using a suitable front-end attachment.

The Eagle Hitch is an integral part of the tractor, not an attachment, permitting close coupling of tractors and implements. With most Eagle Hitch implements, the operator simply backs the tractor to the machine, slips in a pin and drives away. In other words, he can hitch while sitting on the tractor seat. This takes about a minute. Working depth can be adjusted from the tractor seat by twisting a turnbuckle. Leveling, lifting and lowering controls are within easy reach of the operator. An Eagle Hitch provides uniform depth control for mounted implements.



Case Eagle Hitch for SC and DC tractors consists of two draft arms and an adjustable connecting link for quick, easy mounting of implements

The full-floating hydraulic system permits more uniform plowing depth over irregular ground surfaces than is ordinarily possible.

Implements now being manufactured for use on the SC and DC Eagle Hitch tractors include a wide variety of tillage machines, tool bars, planters, mowers, and utility carriers.

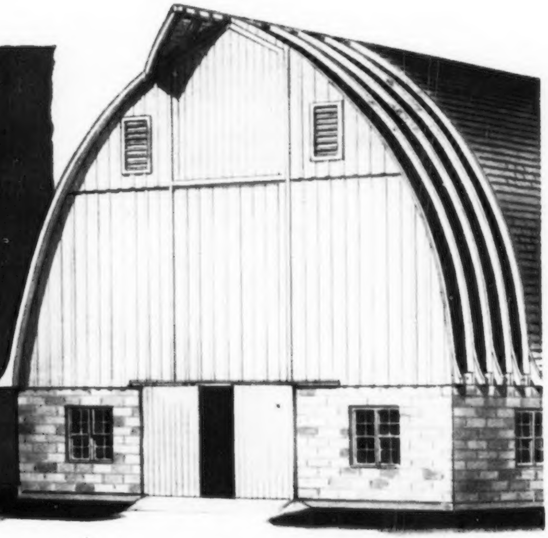
Eagle Hitch implements are interchangeable between SC and DC tractors, and many of them can be used with the VAC. Also certain VAC Eagle Hitch implements can be used on the SC and DC. Where Eagle Hitch equipment is designed for operation with a two-plow tractor, some care must be used by the operator if he attaches such units to the heavier tractors.

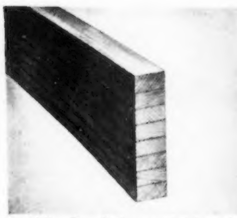
Both the 1952 S and D series tractors can be purchased with a live or continuous-running power take-off. This live power take-off can be operated with the tractor standing still as well as moving. This is especially desirable with such machines as the field forage harvester, corn picker, combine, mower, stalk shredder, sprayer and other units, and a convenience in doing stationary power take-off work.

On these new tractors a hydraulic pump operates continuously and independently of the live power take-off or the transmission, thereby permitting uninterrupted raising, lowering and angling of the implements. Of special interest to the corn grower is the very simple restrictor valve-screw adjustment whereby the corn planter, for instance, can be lowered slowly to the ground to prevent the planter boots from filling up with dirt.

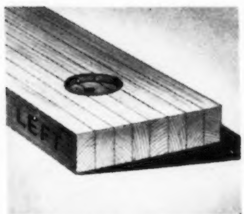
Double-disk, self-energizing differential brakes, proven successful on the Case LA tractor, are now supplied on the S and D series. This more than doubles the capacity of the brakes for holding, assisting in turning, and stopping the tractor. These brakes hold equally well whether the tractor is moving forward or backward. A light touch on the pedal applies pressure on eight braking surfaces. On the SC and DC tractors both pedals are located under the right foot, and can be latched together for equalized braking. Pedals can be locked down to hold for belt and stationary work. *(Continued on page 378)*

Ten easy steps to a BETTER BARN

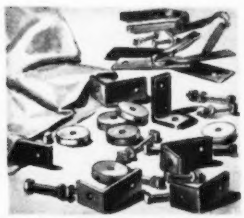




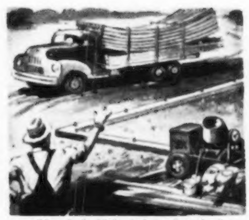
1. Rilco Barn Rafters are finish grade, kiln dried West Coast Douglas Fir laminations bonded together by super-strength structural glues under pressure. They can't warp or twist.



2. Each rafter is precision fitted, cut and drilled at the factory. Every one is plainly marked so even a beginner can't go wrong. There's no time-wasting sawing or fitting on the job.



3. Every bit of connecting hardware is furnished with Rilco Rafters. Engineered connectors make use of 80% of the natural strength of the wood—make buildings more rigid and stable.



4. Nearly half the job is already done when Rilco Rafters are delivered to the barn site all ready to put up . . . and they're four times stronger than nailed rafters built on the job.

5. Building goes fast with Rilco Rafters. First, rafter halves are bolted together at the crown with special steel plates and heavy bolts furnished. Holes are already drilled so job is simple and swift.

6. Next, rafter is raised with ropes and poles. With angle irons bolted to the sill or foundation, a crew can easily erect all the rafters for an average barn in less than a single working day . . . ordinarily a two-week job.

7. Rafters are securely bolted to sill with sturdy steel angle irons and engineered timber connectors. They can't "creep" or twist out of position as often happens when ordinary studs are toenailed to sill.

8. Rilco Rafters give you the strength of a single, solid, joint-free member clear from foundation or plate to roof ridge. There's no chance for loosening or sagging as in ordinary construction (right).

9. The mow of a Rilco Barn is completely free of inside posts or supports. The vaulted arch design of Rilco Rafters places the load squarely and securely on the foundation . . . gives you more space.

10. This illustrated direction book takes a barn builder through every operation step by step. Clear directions plus Rilco pre-engineering helps even unexperienced builders do a perfect job.

RILCO WORKS WONDERS WITH WOOD

Laminated **PRODUCTS, INC.**

SAINT PAUL 1, MINNESOTA

There are standard, pre-engineered Rilco Rafters, for every type of farm building from small hog and poultry houses to large post-free machine sheds, granaries and barns.

NEWS FROM ADVERTISERS

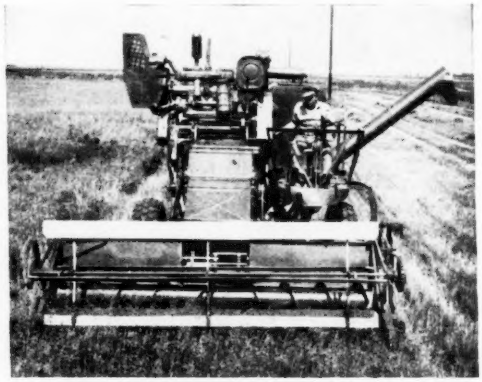
(Continued from page 376)

The shockproof, high-leverage steering adds to the comfort of the operator, especially when traveling over rough ground. The operator is located between the platform seat and steering wheel, which permits a full day's tractor operation with minimum fatigue because of the natural position of the operator.

New McCormick Harvester-Thresher. International Harvester Co., Chicago, has announced the production of a new self-propelled harvester-thresher, the McCormick 127-SP, having 36 forward speed adjustments for harvest control. The new combine, which replaces the McCormick 125-SP, features 16 major improvements for ease of operation and efficiency over a wide range of grain and field conditions.

A new variable-speed, V-belt propulsion drive makes available the 36 forward travel speed adjustments. Nine different speeds in each of the four transmission gears range from $\frac{3}{4}$ to $12\frac{1}{2}$ mph. The operator can match travel speed with crop conditions to operate the combine at maximum efficiency without shifting gears or throttling the engine. The separator speed stays constant and the engine speed and power remain full at all times.

Power of the top-mounted engine has been increased to 49.8 hp. It is an IH 6-cylinder, valve-in-head engine with 240 cu in displacement.



The new McCormick 127-SP harvester-thresher with 36 forward travel adjustments to allow the operator to match speed with crop and ground conditions without shifting gears or throttling down

Cooling and oil-circulating systems are pressurized. It is self contained and can be removed for use as a power unit.

A variable speed cylinder drive provides a complete range of speeds for any crop. A complete redesign of the cylinder support and adjustment assembly makes cylinder-to-concave spacing a simple matter. An accurately marked and positioned gage is provided, eliminating use of a feeler gage.

The cutting platform, now available in 10, 12 or 14-ft sizes, is hydraulically operated with an engine-driven pump for smooth control, and can be instantly adjusted up to $39\frac{1}{2}$ in, a 9-in increase over the 125-SP.

All engine gages and controls, gearshift, propulsion drive lever and unloading auger control have been placed within easy reach. Foot brakes for use in making sharp turns are directly in front, and the grain level in the tank can be seen without leaving the seat.

Capacity of the grain tank has been increased to 55 bu. A distributor on the clean grain auger levels the grain in the tank. The unloader is driven by a pulley on the same shaft as the lower propulsion sheave, making it possible to unload grain whether the machine is moving or stopped. Auger speed can be changed by varying engine speed, propulsion drive, or both. Wheat and barley can be unloaded at a bushel-per-second rate. An improved swivel-type unloader support enables one man to quickly place the unloader in either transport or unloading position. In transport position the unloader is no higher than any other part of the combine.

Weight distribution on the drivewheels has been improved by top-mounting the engine and relocation of the grain tank. When the grain tank is half full the weight on the drivewheels is equalized and results in better stability in rough terrain, and increased traction.

Guide wheels are centrally located for increased maneuverability. It can be turned equally short in both directions, the wheel turn radius being only 7 ft. This reduced radius is accomplished through the use of individual wheel brakes.

(Continued on page 380)

NEWS FROM ADVERTISERS

(Continued from page 378)

Other improvements include a receding finger platform auger to prevent wrapping in fluffy straw conditions; belt-driven straw spreader; improved brakeshoe pivots for more positive braking; new axle shield to keep straw off steering assembly; reinforced concave for minimum distortion; new perforated steel radiator screen for self-cleaning; new guidewheel carriage of stronger, simpler construction; new separator top door which also can be raised for use as a platform for inspecting the engine.

The new combine can use all special equipment formerly used with the 125-SP, plus about a dozen new attachments made only for the 127-SP. These attachments are made to adapt the machine to special crops and to unique harvesting and field conditions.

The 127-SP can be had with grain tank or bagging attachment; with 10, 12 or 14-ft cutting platform, or with windrow pickup attachment. All the feeding and threshing features of the 125-SP have been retained.

Massey-Harris Liquid Petroleum Tractors. Massey-Harris Co., Racine, Wis., announces two new LP (liquid petroleum) tractors, factory designed for operation with low-cost liquid petroleum gas. The 3-4 plow 44 LP and the 4-5 plow 55 LP have all the advantages of the regular

Massey-Harris 3-4 plow 44 LP row-crop tractor

44 and 55 series gas tractors plus the efficiency, low maintenance and fuel costs of butane-propane operation.

The new models feature a special fuel filter. Fuel leaving the tank passes through an element consisting of felts and screens which catches the dirt and scale, depositing them in a settling bowl, thereby assuring a clean fuel supply. The element may be removed for servicing in a few minutes.

A unique regulator conditions the fuel. This high-pressure regulator, vaporizer and low-pressure control are contained in a single unit. It converts the liquid butane-propane to a dry gas, reduces the pressure to less than atmospheric pressure and delivers it to the carburetor in correct volume.

An updraft carburetor is another Massey-Harris LP engine feature. A manual choke sets into operation a separate set of air and fuel inlets for easy starting. Fuel consumption is controlled at part loads by the Massey-Harris "economizer jet".

Linked directly to the carburetor, the built-in governor controls fuel delivery to match the load, it being sensitive to load and speed demands. The governor is pressure lubricated.

Massey-Harris LP tractors are equipped with heavy-gauge steel tanks that exceed the strength required to store LP gas under adequate pressure. It is tested under close supervision and meets all of the legal conditions affecting the storage of liquid petroleum gas. As added insurance, the tanks have relief valves set to open at a pressure of 250 psi. Another safety valve automatically closes, shutting off the fuel supply if for any reason the fuel lines become separated.

Standard size filler inlets permit refilling from a central supply, from the same supply the farmer may use for other utilities on the farm. A rotary gauge on the tractor tank determines the supply level and also provides a means of holding refills to 80 per cent of tank capacity to provide adequate expansion area.

Massey-Harris LP tanks carry enough fuel for close to a day's work at maximum drawbar horsepower. The tank on the 55 at full volume is 46½ gal, on the 44 Row Crop, 34 gal, and on the 44 standard, 32½ gal.

The 44 LP tractor is built in row-crop, high-arch, single front wheel, and standard models. Speeds on 12-38 tires are 2.48, 3.75, 4.98, 6.47 and 13.80 mph; reverse is 3.26 mph. A special rice 44 LP is also available.

The 55 LP is available in standard (foot or hand-operated clutch), riceland, and western models. Speeds on 14-34 tires are 2.96, 4.22, 12.07 mph, reverse 2.54 mph.

Other important features of the new tractors include shock-resistant steering, adjustable roller-type drawbar for either fixed or swinging operations; a hydraulically controlled coil spring, cushioned seat to eliminate rough-riding; a heavy-duty clutch to assure full power delivery, less slippage and power loss. The clutch release bearing is permanently sealed in a special lubricant.

Both models are available for operation with the Massey-Harris depth-o-matic 2-way hydraulic system.

International Nickel Co. Distributes Corrosion Paper. "A Theory of the Mechanism of Rusting of Low Alloy Steels in the Atmosphere," by H. R. Copson, has been reprinted from proceedings of the American Society for Testing Materials, for further distribution by the International Nickel Co. to interested persons. When originally presented in 1945, this paper won for the author the Dudley Medal of the ASTM. It still represents advanced technology in its particular field. The theory presented is based on results of exposure tests on 71 low alloy structural steels and explains the improved corrosion *(Continued on page 382)*

NEWS FROM ADVERTISERS

(Continued from page 380)

resistance secured by the addition of nickel to steel. In 6 x 9-in bulletin size, the text and accompanying tables, graphs and illustrations fill 38 pages. Copies are available on request to International Nickel Co., Dept. FZ, New York 5, N. Y.

Dearborn One-Way Plow. Dearborn Motors Corp., Birmingham, Mich., has added a one-way plow to its line of farm equipment. This plow can be used for a wide variety of jobs including cutting and weeding irrigation ditches, building terraces and plant beds, cutting stalks and disking down vegetable crops, leveling corn fields and preparing seedbeds.

The plow has a cutting width of 4½ ft and can plow up to 20 acres per day. Engineered for use with the Ford tractor, this implement is positively controlled by Ford tractor hydraulic touch control for working depths of from 1 to 6 in.

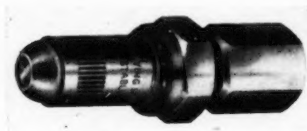
Dearborn one-way plow

The plow has 8 disks 22 in in diameter, made of heavy, shock-resistant 9-gauge, high-carbon steel. Built to take hard, rugged usage, the heavy rigid frame is made of 4 x 4 angle steel to insure long life.

The plow can be quickly and easily attached to the Ford tractor's three-point hydraulically lifted hitch links. An 18-in cutout coulter and a stabilizer bar are furnished as standard equipment.

The plow gang is carried on two heavy-duty dustproof roller bearings. Weighing approximately 575 lb, the implement has a 10-in road clearance in transport position on the Ford tractor.

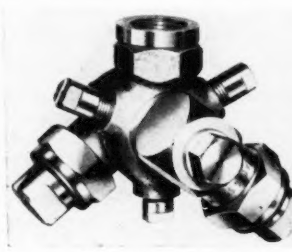
Spraying Systems Spray Nozzle Tip. Spraying Systems Co., Maywood, Ill., announces a new compact spray nozzle tip for use with portable sprayers, that permits varying the spray from a solid stream to a finely atomized cone spray. This unit is named the Adjustable Conejet Tip, weighs only 1½ oz, and fits the standard TeeJet spray nozzle body and the Trigger TeeJet. It is designed for spraying



SS spray nozzle tip

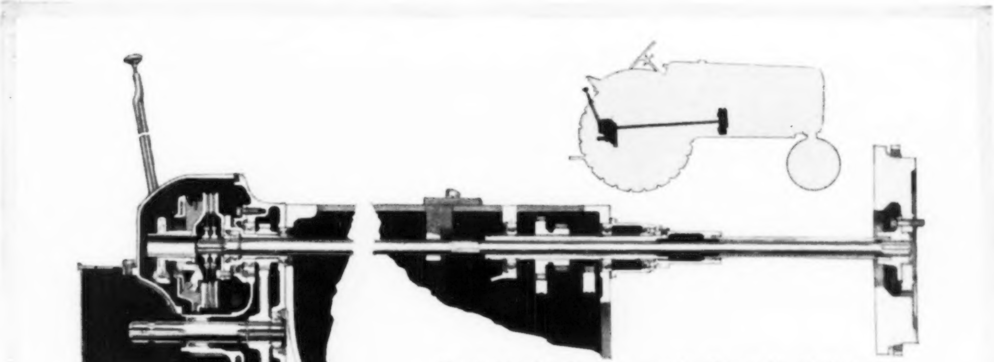
such liquids as insecticides, herbicides, and fungicides, and is supplied in capacities, depending upon pressure, from 1 to 112 gph. Any setting to select spray desired is obtained by rotating the knurled body of the tip; only a half turn is needed for full range selection from solid stream to finely atomized cone spray. For complete information write the company for Bulletin No. 63.

Spraying Systems Boomjet Spray Nozzle. Spraying Systems Co., Bellwood, Ill., has a new spray nozzle that, mounted on a tractor or truck, will spray to a width of up to 66 ft, using only this single-nozzle assembly for the job. This nozzle provides full coverage over the entire width of the spray pattern. The assembly consists of five nozzle tips, two of



SS boomjet spray nozzle

which are swivel mounted for adjustment; together the five tips give a balanced coverage of spray across the pattern area. Spray is directed equally to either side of the Boomjet nozzle. It is also supplied in a similar design for spraying to one side only, and is designed for field and road spraying of every kind. It is built in a range of sizes to give capacities, depending upon pressure, of from 1.0 to 20.8 gpm. For complete information write the company and ask for Data Sheet 5430.



Applicants for Membership

The persons listed below have applied for admission to membership or for transfer of membership grade, in the American Society of Agricultural Engineers. Members of the Society who wish to commend or object to any of these applicants should write the Secretary of the Society at once.

AVERY, A. RUSSELL — Student, Oregon State College, Corvallis, Ore.

BERMANN, BERNHARD R. — General service manager, Harry Ferguson, Inc., Detroit, Mich.

COOPER, JIMMIE D. — Agricultural engineer, Office of Indian Affairs, USDI, Kayenta, Ariz.

DE ALMEIDA, EVANDRO—Regional agricultural engineer, Secretaria da Agricultura, S. Paulo, Brazil, S. A.

DREYFUSS, HENRY — Industrial designer, 4 West 58th St., New York, N. Y.

HARVATIN, LOUIS J. — Student, University of Illinois, Urbana, Ill.

HEIDEGER, EDWARD D.—District sales representative, Cleveland Graphic Bronze Co., Chicago, Ill.

HIGGS, JAS. A. — Vice-president, Higgs & Young, Inc., Staunton, Va.

HUBER, JOHN R.—Student, University of Illinois, Urbana, Ill.

JOHNSON, LOWELL A. F.—Farm products research, Rilco Laminated Products, Inc., St. Paul, Minn.

KING, FORREST H., SR. — Assistant district manager, International Harvester Co., Richmond, Va.

KOCH, EARL E. — Engineering trainee, New Holland Machine Co., New Holland, Pa.

LANE, JOHN E. — Field engineer, industrial div., The Timken Roller Bearing Co., Moline, Ill.

LLOYD, JAMES E.—Salesman, Delta Implement Co., Indianola, Miss.

MASTERMAN, CHARLES W.—Advertising manager, Rilco Laminated Products, Inc., St. Paul, Minn.

MCGUIRE, FRANCIS T. — Manager, materials engineering dept., Deere & Co., Moline, Ill.

MUMGAARD, MILO L.—Farm electrification extension specialist, University of Nebraska, Lincoln, Nebr.

NELSON, GERALD H.—Student, University of Illinois, Urbana, Ill.

O'DONNELL, PATRICK J.—Consulting engineer, Department of Agriculture, Magheraboy, Sligo, England

OLSON, HOWARD M.—Superintendent, Williston Experimental Substations, Williston, N.D.

PAUL, EDWIN A.—Application engineer, Baldwin-Duckworth Div. of Chain Belt Co., Springfield, Mass.

PENNOCK, ROBERT H., JR.—Agricultural sales engineer, The Ohio Power Co., Portsmouth, Ohio

PORTER, LESTER J.—Production manager, Skow Moccasins, Inc., Skowhegan, Me.

PRICE, VIRGIL C.—Supervisor, V-belt development section, Gates Rubber Co., Denver, Colo.

PRITT, HAROLD L.—Designer, New Holland Machine Co., New Holland, Pa.

QUACKENBUSH, TYLER H.—Head, irrigation section, Soil Conservation Service, USDA, Washington, D. C.

RALSTON, DAVID C. — Agricultural engineer trainee, (SCS), USDA, Freeport, Ill.

RALSTON, HAROLD A.—Field test engineer assistant, J. I. Case Co., Rockford, Ill.

RANDALL, DUANE A.—Salesman, Spurlin & Robnett, Corvallis, Ore.

RANDOLPH, EDWARD F.—Designer, Harry Ferguson, Inc., Detroit, Mich.

RIEL, ROBERT—Sales engineer, General Tire & Rubber Co., Wabash, Ind.

SHULTS, CHARLES O.—Rural electrification advisor, Warren Rural Electric Co-operative Corp., Bowling Green, Ky.

SKAUGE, ARTHUR M.—Instructor, Institutional-on-Farm Training Program, Fairfax, Minn.

SLACK, NORMAN L.—Student, University of Illinois, Urbana, Ill.

SLOAN, WILLIAM W.—Rural service director, Nantahala Power & Light Co., Franklin, N. C.

SWECKER, GERALD E.—Trainee, New Holland Machine Co., New Holland, Pa.

THOMAS, ELIJAH L., JR.—Student, University of Arkansas, Fayetteville, Ark.

VAN BUSKIRK, E. MELVILLE—Layout draftsman, advanced engineering dept., International Harvester Co., East Moline, Ill.

WHITE, LAWRENCE A.—Sales engineer, H. B. Owsley & Son, Charlotte, N. C.

YODER, ELMON E.—Field engineer, Benton-Lincoln Electric Co-operative, Corvallis, Ore.

NEW BOOKS

THE MIAMI CONSERVANCY DISTRICT, by Arthur E. Morgan. Cloth, xiii + 504 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc. (330 W. 42nd St., New York 18, N. Y.) $6.50.

This is an historical account of the development of a unique major engineering project for flood control and related purposes, written from the perspective of the 38 years which have passed since its inception and 28 years since its completion. The author was chief engineer of the project during its development and has been widely acclaimed as one of the major contributors to its original engineering features and ultimate success. Chapters cover The Miami Valley, The Miami River Flood of March, 1913, Relief, Emergency government, Flood control, The Ohio Conservancy Act, Organization of the Miami Conservancy District, The official plan, The engineering staff, The appraisal and assessment, Preparing for construction, By-products and incidentals, Methods and policies of construction, Industrial relations, The construction period, As the years pass, and The influence of the Miami Conservancy District.

ELEMENTS OF PLANT PROTECTION, by Louis L. Pyenson. Cloth x + 538 pages, 5½ x 8 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.; London, Chapman and Hall, Ltd.) $4.96.

This is a vocational-agriculture text and reference of high school or junior college level emphasizing biological factors, but including three chapters on application equipment for insecticides, fungicides, herbicides, and other chemicals. Individual chapters cover: The external and internal structure of insects; the development of insects; the seasonal life history of insects; the relationship of insects to other organisms; invertebrates other than insects harmful to plants; control of insects and other invertebrates; the chemical control of insects, the stomach poisons; the chemical control of insects, the dormant and summer contact insecticides; the chemical control of insects, fumigants and spray supplements; the chemical control of insects, the new synthetic organic insecticides; mammals and birds injurious to agriculture; control of vertebrate animal pests; plant diseases; causes of plant diseases; the annual life history of pathogenes; viruses and physiopaths as the cause of plant diseases; the control of plant diseases; plant treatments for disease control; weeds; the reproduction of weeds; the elements of weed control; chemical methods of weed control; selective herbicides; selective herbicides other than 2,4-D; pre-planting and pre-emergence weed control; application equipment I; application equipment II; selection, care, and manipulation of application equipment.

THE DESIGN AND ANALYSIS OF EXPERIMENTS, by Oscar Kempthorne. Cloth, xix + 631 pages, 6 x 9 inches. Indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.). $8.50.

This is a comprehensive treatise on the subject from the standpoint of producing and interpreting statistical values. As a text it will be useful primarily for students specializing in statistics and related design of experiments. As a reference it is indicated to be of probable value to biological scientists in general. It may also prove of considerable reference value to research agricultural engineers, due to the extent to which their work involves experimental methods and the interpretation of biological statistics. Chapters cover introduction, the principles of experimental design, elementary statistical notions, an introduction to the theory of least squares, the general linear hypothesis or multiple regression and the analysis of variance, the analysis of multiple classifications, randomization, the validity of analyses of randomized experiments, randomized blocks, latin squares, plot technique, the sensitivity of randomized block and latin square experiments, experiments involving several factors, confounding in 2^n factorial experiments, partial confounding in 2^n factorial experiments, experiments involving factors with 3 levels, the general p^n factorial system, other factorial experiments, split-plot experiments, fractional replication, the general case of fractional replication, qualifactorial or lattice and incomplete block designs, lattice designs, lattice designs with two restrictions, rectangular lattices, balanced incomplete block designs, partially balanced incomplete block designs, experiments on infinite populations and groups of experiments, and treatments applied in sequence.

PETROLEUM FACTS AND FIGURES (ninth edition, 1950). Paper, 491 pages, 6 x 9 inches. Indexed. American Petroleum Institute (50 West 50th St., New York 20, N. Y.) $2.50.

Tabulated data on utilization, production, refining, transportation, marketing, prices and taxation, and other general information on the industry. Tabulations by years, areas, industries and other factors give a picture of trends.

REPAIRING AND CONSTRUCTING FARM BUILDINGS, by J. C. Wooley. Cloth, xii + 261 pages, 6 x 9 inches. Illustrated and indexed. McGraw Hill Book Co., Inc. (330 West 42nd St., New York 36, N. Y.) $3.20.

This is a text for students of agriculture and future farmers, and a reference for farm operators. The first part, on repairing, covers termi-

nology of repair and construction; disposing of roof and yard drainage; repairing foundations; repairing basement walls and floors; repairing and replacing parts of barn frames; repairing and re-covering exterior walls; repairing windows and repairing and replacing doors; repairing and re-covering old roofs; insulating old buildings; ventilating existing buildings; repairing silos; and repairing ceilings, walls, and floors in farm houses. Part II, on constructon, covers staking out a new building; excavating for construction of farm buildings; mixing and placing concrete; constructing a foundation; erecting the framework of a farm building; framing gable, gambrel, and hip roofs; framing gothic-roof buildings; and constructing yard fences and gates.

Appendices give brief supplementary information on general-purpose lumber, wood fasteners, paint, wood preservatives, definitions, and a list of visual aids.

Range Management Principles and Practices, by Arthur W. Sampson. Cloth, xiv + 570 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N.Y.) $7.50.

A college text and practical reference on the subject, this work has chapters grouped under four main headings as follows: Part 1. Range management in perspective—concepts on range management and on products of the range, the world's grazing practices and problems; physiological principles as applied to range problems; plant ecology as applied to range problems; physical and vegetal characteristics of United States grazing lands; historical development of grazing in America; Part 2. Native range forage plants—forage plants as a basis of range production; discussion of three tribes of range grasses; other native range grasses, and grasslike forage plants; important western forbs and shrubs as stock-food plants; Part 3. Improvement and management of range and stock—artificial reseeding, and the establishment of irrigated pastures; natural reseeding and systems of grazing on western ranges; control of noxious woody vegetation on range lands; management considerations common to ranges and range livestock; management of cattle, sheep, and goats on the range; range condition and trend as guides to better management; range utilization; range inventories and management planning; some economic, physical, and social aspects of ranching; Part 4. Protection of land resources and range livestock—protection of timber reproduction and use of shade trees and shelterbolts; stock-poisoning range plants, their recognition and control; foraging and predatory wildlife of the range; soil erosion and its control; and administration of public grazing lands.

NEW BULLETINS

Slope Discharge Formulae for Alluvial Streams and Rivers, by E. C. Schnakenberg. Reprinted from the Proceedings (Vol. 37, 1951) of the New Zealand Institution of Engineers (Wellington). A paper by the author, together with discussion by other authorities, on river discharge gagings by current meter, with resulting derived values of n and S in Manning's and Kutter's formulas and consideration of the interpretations which may be placed on those values.

Some Yields of Wood Research, by E. George Stern. Wood Research Laboratory, Virginia Polytechnic Institute (Blacksburg), paper No. 7 (April 1952). Brief summaries and illustrations of 14 developments relating to wood use in various types of construction.

Tests of Fence Post Preservatives, by Xzin McNeal. Arkansas Agricultural Experiment Station (Fayetteville), Bulletin 519 (March, 1952). Reports results of several treatments in comparison with untreated check for 15½-yr period, under North Arkansas conditions. Commercial pressure creosote treated posts showed best results, with all specimens still standing at the end of the test period. All of the untreated checks were broken before the end of the test. Other treatments showed results through a wide range between these limits. Heart wood, sap wood, slow growth, and fast growth influenced results considerably in the case of several of the treatments.

Space Requirements for Kentucky Farm Homes, by J. N. Krueger and J. B. Kelley. Kentucky Agricultural Experiment Station (Lexington), Circular 71 (March, 1952). A room by room summary of space requirements, in 14 pages.

Material and Construction Specifications for Kentucky Farm Homes, by J. N. Krueger and J. B. Kelley. Kentucky Agricultural Extension Service (Lexington), Extension Circular 492 (February, 1952). Brief recommendations on important structural features from footings to millwork and hardware.

Lateral and Vertical Pressure of Granular Material in Deep Bins, by Robert A. Caughey, Calvin W. Tooles, and Alfred C. Scheer, Iowa Engineering Experiment Station (Ames) Bulletin 172 (November, 1951). Reports research methods, results, and conclusions based on tests of a variety of granular materials including sand, pea gravel, portland cement, wheat, and shelled corn. Single copies free on request while the supply lasts.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: 1951 — OCTOBER — O-401-544, DECEMBER — O-473-550, 480-551. 1952—JANUARY—O-484-553. FEBRUARY—O-503-556, 502-557. MARCH—O-537-558, 552-560, 559-561, 576-562. APRIL—O-592-564, 596-565, 584-566, 602-567, 603-568. MAY—O-619-570, 623-571, 630-572.

POSITIONS WANTED: OCTOBER — W-391-78. DECEMBER — W-459-81, 464-82, 454-84. 1952 — FEBRUARY — W-504-92, 528-95. MARCH—W-514-97, 538-100, 542-102, 560-103, 566-104, 573-105, 564-106. APRIL—W-588-107, 590-108, 592-109, 612-111. MAY—W-608-112, 604-113, 626-114, 629-115, 601-116.

NEW POSITIONS OPEN

CHIEF ENGINEER for design and development of high pressure pumps, sprayers and other agricultural equipment, with manufacturer in Midwest. Engineering graduate with 4 yr or more experience in designing farm machinery or related equipment. Must be honest, industrious, and ambitious. Good opportunity for advancement. Want applications only from well qualified men. Age 30 or over. Salary open. O-657-573

ASSISTANT PROFESSOR of agricultural engineering for research and teaching primarily in land reclamation and irrigation, with some teaching in farm structures or machinery, in a state college in the North Central area. MS deg in agricultural engineering, with a major in irrigation engineering or soil and water relationships. Research and teaching experience in irrigation and land reclamation. Proven ability in field. Irrigation farm background highly desirable. Opening available July 15. Opportunity for advancement good. Salary open. O-672-574

NEW POSITIONS WANTED

EXTENSION, teaching, writing, or management in power and machinery or rural electrification, with industry or public service. Any location. MS deg 1943 with major in farm machinery; PhD, 1952, Cornell University. Farm background. Teaching, research, administrative, and supervisory experience, 15 yr. Married. Age 37. No disability. Available June 1 or August 1. Salary open. W-640-117

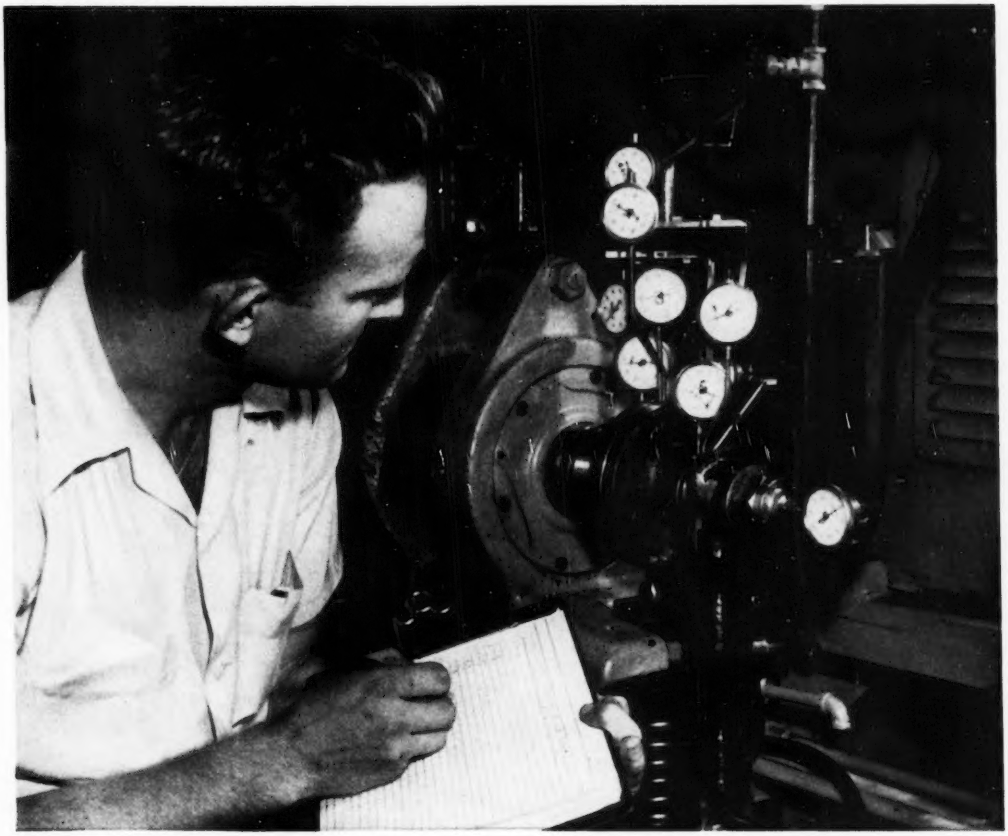
WRITING, or management in power and machinery or rural electric field, with industry, preferably in South but will consider other locations. Occasional travel. BS deg in agricultural engineering, 1944, University of Georgia. Truck farm background. Part time assistant manager of creamery while in school. Instrument man with state highway department one year. Department manager with farm store 5 yr, including experience in sales, merchandising, promoting customer good will, training personnel, and related detail work. War commissioned service in USNR. Married. Age 30. No disability. Available on 30 to 60 days notice. Salary open. W-633-118

DESIGN in power and machinery field with manufacturer, any location. Willing to travel. BS deg in agricultural engineering, 1949, University of Idaho. Farm background. Combine, automotive, and tractor mechanic 5 yr. Junior engineer on field testing and design of harvesting machinery components with leading manufacturer, 2 yr. War service in Army, 2 yr. Married. Age 28. No disability. Available on 60-day notice. Salary $4800 min. W-636-119

EXTENSION, teaching, research, or writing in farm structures, soil and water, or irrigation engineering, with industry or public service in Texas or other southwestern states. Limited travel. BS deg in agriculture, 1950, A & M College of Texas. Farm background. Engineering aide, SCS, 2 yr. Agricultural engineer, SCS, 2 yr. Farm building design and drafting, Extension Service, 3 yr part time. War service in Infantry and Air Force 22 mo. Married. Age 28. No disability. Available on 30 days notice. Salary open. W-674-120

DEVELOPMENT, sales, or service in power and machinery or soil and water field with industry. Any location in U.S.A. Other, South America. BS deg in agricultural engineering, 1951, University of Maine. Farm background. Carpenter and construction worker 10 mo. Summer work on survey for gas company. Present work, production manager, Skowhegan Moccasins, Inc. War enlisted. Service in Navy one year, shipfitter 3/C. Married. Age 25. No disability. Available now. Salary $4000. W-678-121

DESIGN, development, research, or sales in power and machinery, with industry. Any location. BS deg in agricultural engineering, 1951, Michigan State College. Farm background. Design and drafting in research engineering department of farm equipment manufacturer. Single. Age 21. Limited vision, left eye. Available on reasonable notice. Salary open. W-661-122



Theories proved or exploded here

• Before you place a new design on the market, it is important that you know how it will work under operating conditions.

Where the design involves the use of anti-friction bearings, New Departure's new, ultra modern testing laboratory can determine *in advance* what performance you can expect "in the field".

Furthermore, as the study progresses, New Departure engineers may find it possible to improve the performance or the assurance of success by applying their ingenuity and their fund of knowledge and over forty years experience to the subject at hand.

May we work with you on your anti-friction problems?

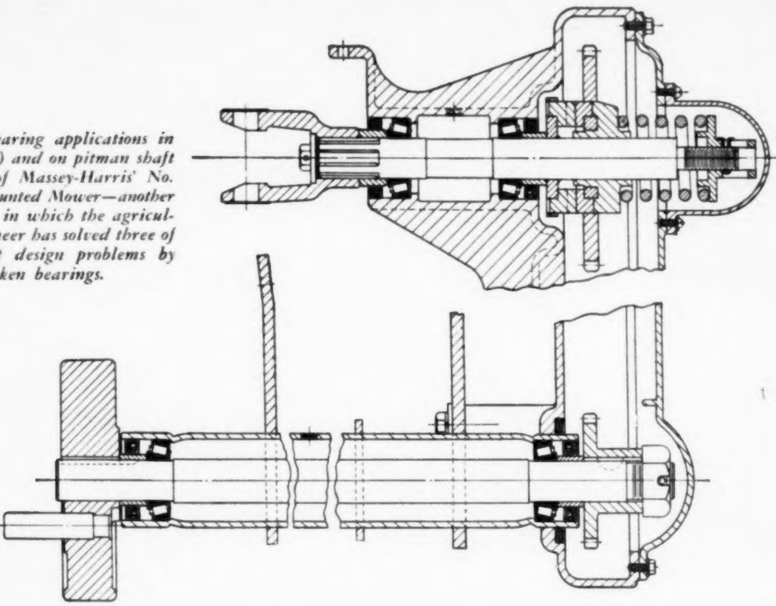
Nothing Rolls Like a Ball . . .

NEW DEPARTURE
BALL BEARINGS

168

NEW DEPARTURE • Division of GENERAL MOTORS CORPORATION • BRISTOL, CONNECTICUT • BRANCHES IN ALL PRINCIPAL CITIES

EVERY NEW FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!



Timken bearing applications in drive (top) and on pitman shaft (bottom) of Massey-Harris' No. 41 Side-Mounted Mower—another implement in which the agricultural engineer has solved three of his biggest design problems by using Timken bearings.

How Massey-Harris licks dirt and load problems, assures easier mower operation

BY specifying Timken® bearings for the drive and pitman shaft of their No. 41 Side-Mounted Mower, Massey-Harris engineers solved these three big design problems at once:

1. DIRT. Timken bearings hold housings and shafts concentric, making seals more effective. Dirt and mud are kept out—lubricant is kept in.

2. COMBINATION LOADS. Because Timken bearings take both radial and thrust loads, shafts are held in positive alignment. Deflection and end-play are minimized.

3. EASE OF OPERATION. Due to true rolling motion and incredibly smooth surface finish, Timken bearings practically eliminate friction. Moving parts rotate freely, make mower operations smoother and easier.

Timken bearings lick dirt and load problems and assure easier implement operation — they also mean longer implement life, less chance of breakdown in the field, higher speeds and less frequent lubrication.

For more information about Timken bearings, write now for your free copy of "Tapered Roller Bearing Practice On Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION